NORTHEAST FLOOD STUDIES

INTERIM REPORT
ON
REVIEW OF SURVEY

BLACKSTONE RIVER BASIN
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
BLACKSTONE, MILL, AND
PETERS RIVERS, R.I.

U.S. Army Engineer Division, New England

Corps of Engineers

Boston, Mass.

MAY 29, 1957

ARMY NED BOSTON

SYLLABUS

The Division Engineer finds that there is urgent need for revision of the existing flood control project on the Blackstone River and tributaries to insure the stability of present development, the security of the inhabitants, and the preservation of existing economic values. He finds that the Blackstone River produces major flood damages in Woonsocket, Rhode Island, in the area downstream from the existing Woonsocket Local Protection Project. In this area the record flood of August 1955 caused losses of $12,300,000. He concludes that additional local flood protection in the City of Woonsocket is necessary and warranted.

The Division Engineer recommends that the authorized plan for flood control in the Blackstone River Basin be revised to include the Lower Woonsocket Local Protection Project. The total estimated first cost of the project is $4,255,000 plus the cost of Bernon Dam water rights, and the estimated first cost to the United States is $2,970,000. He recommends that local interests be required to (1) contribute to the United States approximately 16.1 percent of the construction cost, which contribution is presently estimated at $570,000; (2) provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction and operation of the project; (3) hold and save the United States free from damages due to the construction works; and (4) maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army.

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U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
150 Causeway Street
Boston 14, Mass.

SUBJECT: Interim Report for Flood Control, Blackstone River Basin, Lower Woonsocket Local Protection Project on the Blackstone, Mill, and Peters Rivers, Woonsocket, Rhode Island

TO: Chief of Engineers
Department of the Army
Washington, D. C.
ATTENTION: ENGWF

1. AUTHORITY

This report is submitted pursuant to authority contained in a Resolution of the Committee on Public Works of the United States Senate adopted September 14, 1955, 84th Congress, 1st Session, which provides:

> "That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review previous reports on the . . . Blackstone River, Massachusetts and Rhode Island . . . in the area affected by the hurricane flood of August 1955, to determine the need for modification of the recommendations in such previous reports and the advisability of adopting further improvements for flood control and allied purposes in view of the heavy damages and loss of life caused by such floods."

2. SCOPE OF SURVEY

2.1 Scope.- This is an interim report of survey scope which reviews a portion of the Blackstone River in Woonsocket, Rhode Island, in partial compliance with 1st indorsement dated 16 September 1955, from the Chief of Engineers, to letter from the Senate Public Works Committee, dated September 1955, subject: "Northeastern States Hurricane Flood Study."

The report reviews the flood control problem in Woonsocket, Rhode Island, in the area downstream from the existing project. This area, referred to in this report as the Lower Woonsocket flood area, lies along the banks of the Blackstone River downstream from South Main Street bridge and along the tributary Mill and Peters Rivers in Woonsocket. This report makes specific recommendations in the interest of flood control.

2.2 Topographic surveys.- A plane table survey was made in 1938 of the upstream portion of Lower Woonsocket, on a scale of 1" = 100' with a contour interval of 2 feet. This data was supplemented by property and street maps and topographic data furnished by the City of Woonsocket. In addition, valley sections were obtained in 1956 along the Blackstone, Mill, and Peters Rivers. All available survey and map data for the Lower Woonsocket area was field checked.

2.3 Subsurface explorations.- Explorations in the survey area consisted of a reconnaissance to study the general geology of the area, map bedrock exposures, and determine as far as possible bearing and excavation properties of materials present. Pertinent data utilized to supplement the results of reconnaissance is contained in Design Memoranda 3 and 4: "Geology & Soils" and "Concrete Materials," prepared in 1956 for the existing Woonsocket Local Protection Project, and in a report entitled Geology and Ground Water Resources of Woonsocket, published in 1950 by the Rhode Island Port and Industrial Development Commission. Additional information is contained in Appendix B, "Geology."

2.4 Flood-damage surveys.- Flood damage surveys were made after the floods of July 1938 and August 1955. The surveys consisted of the inspection of properties damaged by the flood and interviews with property owners, officers of industrial concerns, and municipal and state officials. The results of flood-damage surveys are summarized in Sections 11 and 12 of this report. Supporting data is given in Appendix C.

2.5 Conferences with local interests.- Close liaison has been maintained with state and city officials, local property owners, and other interested parties. Plans for the protective works have been reviewed by representatives of the State of Rhode Island and the City of Woonsocket. All have expressed a strong desire for the immediate construction of flood protection works and, in many instances during the course of the study, have furnished valuable information. Letters from the Governor of the State of Rhode Island, and the Mayor of Woonsocket indorsing the project are included in Appendix F.

3. PRIOR REPORTS

3.1 Published report.- Flood control improvements for Woonsocket, Rhode Island, were considered in the Report on Survey for Flood Control: Blackstone River, Rhode Island and Massachusetts, which was submitted by the Chief of Engineers on April 11, 1944, and published in House

Document No. 624, 78th Congress, 2nd Session. It presented the results of an investigation and survey of the Blackstone River and its tributaries for flood control, with collateral studies on pollution, additional power and conservation storage, recreation, and sanctuary for wildlife. Flood control projects recommended and subsequently authorized include a storage reservoir on the West River in Massachusetts and three local protection improvements. One of the three authorized local protection works consists of a project for that portion of Woonsocket upstream from South Main Street bridge. Local protection for the downstream portion of the city was investigated and found to lack economic justification at that time.

3.2 Unpublished report.- A comprehensive report entitled "The Resources of the New England-New York Region," which presents a coordinated plan for watershed development, was prepared by the New England-New York Inter-Agency Committee pursuant to the directive contained in a Presidential letter dated October 9, 1950. The report recommended that the plan be used as a guide for the development, conservation, and use of land, water, and related resources of the region. It also recommended that flood control studies be made of the Blackstone River Basin to determine the economic justification of protection measures in addition to the authorized Woonsocket Local Protection Project.

4. DESCRIPTION OF AREA

4.1 Geography.- The Blackstone River drains an area of 540 square miles in south central Massachusetts and northern Rhode Island. The basin has an elongated shape with a maximum length of 46 miles and an average width of 12 miles. The Blackstone River, originating in Worcester, Massachusetts, flows 49 miles in a general southeast course to Providence, Rhode Island, where it empties into Providence River and Harbor. The lower 4.7 miles of the river, below Main Street in Pawtucket, Rhode Island, is tidal and is generally referred to as the "Seekonk River." Above the tidal section, it is usually called the "Blackstone," although the name "Pawtucket" is sometimes used.

Woonsocket lies along the banks of the Blackstone River in northeastern Rhode Island. It is located 24 miles southeast of Worcester and 16 miles northwest of Providence. Two tributaries, the Mill and Peters Rivers, join the Blackstone River from the north immediately upstream from the U.S.G.S. gaging station near the center of Woonsocket. The drainage area at the gaging station is 416 square miles. A location map is shown on Plate No. 1.

4.2 Topography.- The Blackstone River Basin is generally hilly and exhibits surface characteristics and irregular drainage patterns typical of glaciated areas of southern New England. In the northern and western portions of the basin, hills are prominent and valleys are steep and narrow. In the headwater areas in the vicinity of Worcester, Massachusetts, hills rise to elevations of 1,400 feet above mean sea level. Prominent hills are more widely scattered in the central and southeastern portions of the basin and tributary valleys are wider. The irregular flood plain of the Blackstone River, generally narrow, widens considerably in some areas, particularly near tributary confluences. The river has cut down to bedrock and created natural falls at a number of places in its course through the basin.

The terrain in Woonsocket is typical of the central portion of the basin, with hills of moderate to sharp relief rising to elevations of 410 feet, m.s.l. In the 4.5 mile reach within Woonsocket, the Blackstone River falls from an elevation of 149 feet to 107 feet, m.s.l. The flood plain in this reach is narrow, averaging 500 feet in width, except for extensive widening abutting the confluence of the Blackstone, Mill, and Peters Rivers.

4.3 Geology.- Overburden in the Blackstone River Basin consists largely of glacial till and outwash, with lesser amounts of recent alluvium in the valley bottoms. Outwash sands and gravels occur in the flood plain and lower valley slopes. Till of varying depths and perviousness extends up the hillsides, and rock outcrops are common on the upper slopes and hilltops.

In the Lower Woonsocket survey area, outwash materials constitute the bulk of overburden, with alluvial deposits overlying the outwash and bedrock in portions of the area. Bedrock exposures are numerous at higher elevations. Rock formations consist of granite, gneiss, and steeply inclined strata of schist and shale. Detailed information on the geology of the survey area is contained in Appendix B.

4.4 Description of main river.- The Blackstone River, formed in Worcester, Massachusetts, by the confluence of Middle River and Mill Brook, has a total length of 49 miles. The river flows in a general southeasterly direction for 28 miles, entering Woonsocket at the Massachusetts-Rhode Island state line. It flows through the city in an irregular course that forms several loops. The river meanders southeasterly to the center of the city, turns to the northeast for about a mile, and then resumes a general southeast course to its mouth in Providence, Rhode Island. The total fall within Woonsocket is 42 feet in a distance of 4.5 miles. Of this 42 feet, 37 feet have been developed by three dams for power and industrial processing purposes. Power is no longer being produced at two of these sites.

4.5 Description of tributaries.- Two tributaries, the Mill and Peters Rivers, flow into the Lower Woonsocket survey area. Both enter the Blackstone River from the north near the center of Woonsocket, a short distance upstream from the U.S.G.S. gaging station.

4.5.1 Mill River.- The Mill River, with a drainage area of 34.7 miles, originates at North Pond in Milford, Massachusetts, and flows in a southerly direction for 18 miles to its confluence with the Blackstone River. The Mill River has a total fall of 23 feet in its one mile reach within Woonsocket. Prior to the record flood of August 1955, which destroyed all dams on the Mill River within the city, Harris Pond was impounded by a dam with a head of 36 feet, located at the city limits on the Rhode Island-Massachusetts state line. Four subsidiary dams, used to divert water for industrial purposes, were located downstream from Harris Pond. Use of these dams for industrial water was largely discontinued before the August 1955 flood. None of of these dams has been replaced since this flood.

4.5.2 Peters River.- The Peters River has its source about 4 miles northeast of Woonsocket at the outlet of Silver Lake in Bellingham, Massachusetts. It flows in a general southwesterly direction for 4.8 miles to its junction with the Blackstone River and drains an area of 12.7 square miles. The total fall within Woonsocket is 68 feet in a distance of 1.3 miles. A few feet of this fall are developed at a small mill pond which stores water for industrial processing.

4.6 Maps.- The Woonsocket area is shown on standard quadrangle sheets of the U.S. Geological Survey, scale 1:31,680, and on Army Map Service topographic maps at a scale of 1:25,000. The Army Map Service has issued two topographic maps entitled Boston (NK19-4) and Providence (NK19-7), scale 1:250,000, which together cover the entire Blackstone River watershed.

5. ECONOMIC DEVELOPMENT OF WOONSOCKET AREA

5.1 Population.- Official population figures compiled by the Bureau of the Census, U.S. Department of Commerce, are given below for both the City of Woonsocket and the greater Woonsocket area. The greater Woonsocket area includes the adjacent towns of Blackstone and Bellingham, Massachusetts, and North Smithfield, Lincoln, and Cumberland, Rhode Island.

Year	Woonsocket Population	Greater Woonsocket Population
1930	49,376	81,909
1940	49,303	82,246
1950	50,211	89,117

5.2 Industry.- The textile industry has long been the base of the economy of Woonsocket. There are presently over 50 cotton and wool textile plants engaged in various stages of processing and manufacturing. In addition, there are two large manufacturers of rubber products and machinery. In recent years there has been a decrease in the volume of textile manufacturing in New England and Woonsocket has shared in this loss. During the past few years this trend has been partially offset by the establishment of other types of industry in the mills vacated by textile firms. The new industries were attracted by the quality and availability of skilled labor in the region. Recent additions include manufacturers of plastic and electrical products.

5.3 Transportation.- The Woonsocket area is served by a system of modern transportation facilities, which include several highways, two branch railroad lines, and a nearby airport. The Blackstone River is navigable in its tidal reach below Pawtucket, Rhode Island. Transportation facilities are described in the following paragraphs and the highway system is shown on Plate No. 1.

5.3.1 Highways.- Two State Routes, No. 146 and No. 122, parallel the Blackstone River and provide Woonsocket with connections to Providence, Rhode Island, and Worcester, Massachusetts. Between Woonsocket and North Providence, Route 146 is a modern four-lane divided highway. State Route No. 11, together with Routes 1A and 140 to the east, provide a connection with U.S. Route No. 1 to Boston and other northerly points. Several other hard surfaced, numbered highways connect with the extensive system of state and U.S. routes which serve southern New England.

5.3.2 Railroads.- Two branch lines of the New York, New Haven and Hartford Railroad provide passenger and freight service to the Woonsocket area. One line paralleling the Blackstone River from Providence, Rhode Island, to Worcester, Massachusetts, provides connections to the main line between Boston and New York at Providence and to the main line of the Boston and Albany Railroad between Boston and Albany at Worcester, Massachusetts. The second line, passing through Blackstone, Massachusetts, about 2 miles to the northwest, provides service from Boston southwest to other points in Massachusetts and Connecticut.

5.3.3 Airways.- Northeast Airlines maintains regularly scheduled flights to the North Central Airport in Smithfield, Rhode Island. The airport, located approximately 8 miles south of Woonsocket, serves the Providence - Pawtucket - Woonsocket area.

5.4 Development of water resources.- The Blackstone River was, at one time, one of the most highly developed streams in the nation. Numerous industrial concerns, attracted by potential power sites, availability of process water, transportation facilities, and nearness to markets, located and developed along the main river and its tributaries. Three dams have been constructed on the Blackstone River in Woonsocket, and other dams have been built on the tributary Mill and Peters Rivers. Information on the past and present use of water resources is contained in the following paragraphs. See Tables I and II for pertinent data on dams and water resource developments in the City of Woonsocket.

5.4.1 Power.- In the past, power was developed in Woonsocket at three dams on the Blackstone River and at one on the Mill River. At the present time, all mills in Woonsocket have replaced hydro-power with commercial power. This has been brought about by the availability of low cost electrical power, an increase in the requirements of the mills beyond the available stream flow or the capacity of the installations, and the cost involved in replacing obsolete equipment. Hydro-power is presently developed at Bernon Dam, owned by the Blackstone Valley Gas and Electric Company.

Bernon Dam, with a gross head of 13.7 feet, produced commercial electrical power prior to the record flood of August 1955 which damaged the generating facilities. These facilities have since been repaired and placed in operation. However, representatives of the Blackstone Valley Gas and Electric Company have informally indicated that they would offer no opposition to the removal of the dam as part of a flood control plan, because the generating facilities are old and furnish less than one percent of the city's power requirements.

5.4.2 Industrial water.- The industries in Woonsocket, predominantly textile, require large supplies of water for processing purposes. Water is presently diverted from the main river into canal systems by the Woonsocket Falls Dam and the Hamlet Dam. Numerous mills draw water from the canals for cooling, washing, dyeing, and other purposes. Other plants pump water directly from the river.

Harris Pond on the Mill River, with a capacity of about 1,300 acre-feet, and four subsidiary dams, formerly provided water for power and processing. With the exception of one mill, use of this water was

TABLE I

PAST AND PRESENT USE OF DAMS

BLACKSTONE AND MILL RIVERS IN WOONSOCKET AREA*

Location	Miles Above Mouth	Drainage Area (sq.mi.)	Owner	Product Manufactured	Gross Head (ft.)	Crest Elev. (m.s.l.)	Installed Capacity (HP)	Water Use	Remarks
BLACKSTONE RIVER:									
Manville	14.6	430	Royal Elec. Co.	Electrical Prod.	18.2	106.7	1,206	Power & Processing	Water rights not used. Mill badly damaged by August 1955 flood and destroyed by fire in September 1955. Water rights not in use prior to flood.
Woonsocket (Hamlet Dam)	18.0	369	Blackstone Valley Gas & Elec. Co.	Electric Power	5.3	115.8	-	Power & Processing	Turbines removed. Part of water presently diverted to adjacent mills for processing purposes.
Woonsocket (Bernon Dam)	18.7	369	Blackstone Valley Gas & Elec. Co.	Electric Power	13.7	129.8	503	Power	
Woonsocket (Woonsocket Falls Dam)	19.0	369	Blackstone Valley Gas & Elec. Co.	Electric Power	16.0	148.1	503	Power	All power facilities abandoned. Current use is for processing purposes only. Water rights and maintenance of dam and canal system are administered by a Master of Chancery. Additional abandoned rights are owned by the City of Woonsocket.
			Woonsocket Falls Mill	Velours & Plushes	18.0		523	Power & Processing	
			Lippitt Worsted Mill	Cloth	16.0		200	"	
			Ray Cotton Co.	Cotton and Wool Waste	6.0		160	"	
			Narragansett Knitting Mills	Woolen Goods	8.0		50	Power	
			Clinton Mill (Woonsocket Falls Co.)	Velours & Plushes	18.0		335	Power & Processing	

*Includes dam in downstream village of Manville, since studies include effect of this dam on water surface elevations in Woonsocket.

TABLE I (cont'd)

Location	Miles Above Mouth	Drainage Area (sq.mi.)	Owner	Product Manufactured	Gross Head (ft.)	Crest Elev. (m.s.l.)	Installed Capacity (HP)	Water Use	Remarks
MILL RIVER:									
Woonsocket	0.5	35	Guerin Mills	Cloth	1.7	125.3	-	Processing	Destroyed by August 1955 flood.
Woonsocket	0.5	35	Guerin Mills	Cloth	0.7	126.9	-	Processing	No crest; flashboards only. Destroyed by August 1955 flood.
Woonsocket	0.6	34	Woonsocket Rayon Company	Rayon Yarn	5.7	133.0	-	Processing	Abandoned and subsequently destroyed by August 1955 flood.
Woonsocket (Horseshoe Dam)	0.8	34	Woonsocket Rayon Company	Rayon Yarn	-	162.0	-	Processing	Abandoned and subsequently destroyed by August 1955 flood. This is a secondary spillway and its head is included under Harris Dam.
Woonsocket-Blackstone (Harris Dam)	0.9	34	B. Cohen & Son	Wool Waste	36.0	169.0	400	Power and Processing	Abandoned; later used for recreation and downstream regulation. Dam destroyed by August 1955 flood.

discontinued prior to the record flood of August 1955. This flood destroyed all five dams and terminated this water use entirely. Water from the Peters River is used at one small dam with a negligible amount of storage. Industrial water is also obtained from the municipal water supply and from ground water. See Table II for a tabulation of industrial water used.

5.4.3 Domestic water.- Large quantities of industrial and other wastes which are continuously discharged into the Blackstone and Peters Rivers preclude the use of these streams as sources of domestic water. Woonsocket presently has three municipal reservoirs in the adjacent towns of North Smithfield and Lincoln. These reservoirs are located on Crookfall Brook and yield about 4.4 million gallons per day. Approximately 36 percent of this water is used for domestic purposes by 56,000 persons in the city and in nearby portions of North Smithfield and Lincoln. The balance of this supply is used for industrial purposes.

The city is presently seeking additional sources of domestic water. Plans have been developed for a well system to supplement the existing water supply. Investigations made in 1950 by the Rhode Island Port and Industrial Development Commission indicate that ground water in Woonsocket is probably the most valuable geologic resource in the area and that this resource is presently underdeveloped. The acquisition of Harris Pond on the Mill River and reconstruction of the dam is also under consideration. See Table II for a tabulation of domestic water used.

TABLE II

INDUSTRIAL AND DOMESTIC WATER USED

WOONSOCKET, RHODE ISLAND

Source	Water Used in Gallons Per Day [1]		
	Industrial	Domestic	Total
Municipal Reservoirs	2,840,000	1,585,000[2]	4,425,000
Private Water Supply [3]	2,284,000	-	2,284,000
Ground Water	88,000	-	88,000
Total	5,212,000	1,585,000	6,797,000

[1] Estimated for January 1954.
[2] Serves 50,000 persons in Woonsocket and an additional 6,000 in nearby portions of the towns of Lincoln and North Smithfield.
[3] Water diverted or pumped directly from Blackstone, Mill, and Peters Rivers.

6. CLIMATOLOGY

6.1 Climate.- The Blackstone River Basin has a humid, continental climate, modified by the effects of the Atlantic Ocean. Variable weather conditions within the seasonal regimen are common. The basin has an average annual temperature of 49°F. The mean annual precipitation, based on a preliminary study of New England rainfall made in 1952 by the U.S. Weather Bureau, is about 45 inches. Appendix A contains detailed information on climatology, based on published records of U.S. Weather Bureau stations at Worcester, Massachusetts, and Providence, Rhode Island.

6.2 Temperature.- Average monthly temperatures vary widely throughout the year, from 71°F. at Worcester and 73°F. at Providence in July, to 25°F. at Worcester and 29°F. at Providence in February. Extremes in temperature range from occasional highs slightly in excess of 100°F. to infrequent lows in the minus "twenties," particularly in the northern portions of the basin. The monthly and annual temperature records for Worcester and Providence are given in Table A-I of Appendix A.

6.3 Precipitation.- Maximum and minimum annual precipitation at Worcester, during 102 years of record through 1955, are 61.7 inches and 27.9 inches. Mean monthly rainfalls at Worcester range from a minimum of 3.19 inches in February to a maximum of 4.06 inches in August. During August 1955, a total precipitation of 18.58 inches was recorded at Worcester. The monthly and annual precipitation records for Worcester and Providence are given in Table A-II of Appendix A.

6.4 Snowfall.- About one-third of the precipitation during the winter months is in the form of snow. The annual basin snowfall averages from 30 to 40 inches, with extremes ranging from 30 inches in the southern portions to about 60 inches at northern inland points. The average annual snowfalls at Worcester and Providence for the period of record through 1954 are 56 inches and 33 inches, respectively. The water content of the snow cover over the entire basin in the late winter or early spring seldom amounts to more than 1 or 2 inches. On rare occasions it amounts to over 3 inches at interior locations.

6.5 Characteristics of storms.- Three general types of storms occur in the Blackstone River Basin: continental, coastal, and thunderstorms.

6.5.1 Continental storms.- Continental storms originate over the United States and southwestern Canada and move in a general easterly and northeasterly direction. These storms, of the cyclonic or stationary type, are the most frequent and occur in every season of the year.

6.5.2 Coastal storms.- Hurricanes are the most severe of the coastal storms affecting New England. Although their normal paths carry them east of New England, they are occasionally deflected by continental cyclonic disturbances or by a large, slow moving, anticyclonic center located northeast of New England. In general, hurricanes occur during the months of June through October with the greater incidence of such storms in August and September. Coastal storms of extra-tropical origin travel parallel to the paths of hurricanes, but generally further westward, and cover a much greater area with precipitation. They occur most frequently during the autumn, winter, and spring months.

6.5.3 Thunderstorms.- Thunderstorms occur generally during summer months and are of local origin or associated with a rapidly moving frontal system. Intense precipitation and strong winds affecting relatively small areas are characteristic of these storms.

7. RUNOFF AND STREAM-FLOW DATA

7.1 Stream-flow records.- Stream flow in the Blackstone River Basin is measured at five U.S. Geological Survey gaging stations on the Blackstone River and its principal tributaries. Data on these stations is summarized below.

STREAM GAGING STATIONS

BLACKSTONE RIVER & TRIBUTARIES

Stream	Station	Drainage Area (sq.mi.)	Period of Record
Kettle Brook	Worcester, Mass.	31.3	1923-1956
Quinsigamond	N. Grafton, Mass.	25.5	1939-1956
Blackstone	Northbridge, Mass.	139.0	1939-1956
Branch	Forestdale, R.I.	94.8	1940-1956
Blackstone	Woonsocket, R.I.	416.0	1929-1956

Locations of these stations are shown on Plate No. 1. Records from these stations are generally good to excellent. There are no records of flow on the Mill and Peters Rivers.

7.2 Runoff.- Flow data applicable to the survey area was determined from Woonsocket U.S.G.S. gaging station records. The annual runoff at the Woonsocket gage for 27 years of record, through September 1955, varies from 37.06 inches to 10.62 inches with a mean of 23.00 inches. The mean annual runoff represents approximately 50 percent of the mean annual precipitation. Table A-III in Appendix A gives the monthly and annual runoff record for the Woonsocket gage. Discharge hydrographs for this gage during the period of record (1929-1955) are shown on Plate No. A-1.

8. FLOODS OF RECORD

8.1 Flood causes.- Flooding in Woonsocket is caused by heavy rainfall or heavy rainfall combined with melting snow. Serious floods can be expected to occur during any season of the year. Runoff is rapid due to generally hilly topography and a thin soil cover which is not conducive to infiltration of heavy rainfalls for any appreciable length of time. The flood of March 1936 had two peaks: the first caused by rainfall combined with snowmelt, and the second

by heavy rainfall. Heavy rains during summer and fall months produced the floods of August 1955, July 1938, November 1927, September 1954, and October 1955.

8.2 Historic floods.- Information concerning major floods in the Blackstone River Basin dates back to the beginning of the 19th century. Except for floods which occurred in the past 30 years, information on past floods is scant and general. A list of floods which occurred prior to the establishment of stream gaging stations on the Blackstone River follows:

HISTORIC FLOODS

BLACKSTONE RIVER BASIN

March 1818	February 1886
March 1876	September 1887
March 1877	November 1927

Except for the flood of November 1927, there is no reliable information on the magnitude of these floods. However, available records indicate that they all caused damages.

8.3 Major floods of record.- Reliable records of flood stages and discharges in Woonsocket have been kept since 1929. Five major floods have occurred during the period of record, three of which caused heavy damages in the survey area. A summary of these five floods, including estimated data on the flood of November 1927, is given in Table A-IV in Appendix A.

The March 1936 flood was caused by four distinct storm centers which passed over the northeastern part of the United States between 9 and 22 March. There were actually two flood peaks of about equal magnitude and six days apart. The first peak was caused by a combination of rainfall and snowmelt; rainfall, varying from 3 to 7 inches, produced the second peak. The peak discharge of the November 1927 flood was of the same magnitude as the flood of March 1936, and occurred a few years prior to the establishment of the Woonsocket gage.

Heavy precipitation in the southern half of the watershed produced the flood of July 1938. Flooding in the headwaters was light. The peak discharge at the Woonsocket gage slightly exceeded that of March 1936.

The flood of August 1955 was the greatest flood of record in the Blackstone River Basin. The peak discharge at Woonsocket was about twice the magnitude of the previous record discharge. This flood was the result of 7 to 13 inches of rainfall which accompanied hurricane "Diane" on the 18th and 19th of August and fell on ground previously saturated by 2 to 5 inches of precipitation left by hurricane "Connie" a few days earlier.

9. FLOOD FREQUENCY

The frequency, or percent chance of occurrence in any one year, of peak discharges on the Blackstone, Mill, and Peters River was determined from records of the U.S. Geological Survey gaging station in Woonsocket. The frequency analysis was made in accordance with procedures described in Civil Works Engineer Bulletins 51-1 and 51-14. During high flows on the Blackstone River, a backwater condition occurs resulting in high stages in the lower reaches of the Mill River. Therefore, the discharge-frequency data on the Blackstone and Mill River was related to stage, and a composite stage-frequency curve was developed for the lower reaches of the Mill River. Frequency curves are shown on Plate A-2 of Appendix A.

10. STANDARD PROJECT FLOOD

The standard project flood (SPF) was developed from the standard project storm (SPS) rainfall and an adopted unit hydrograph. The SPS rainfall was based on criteria described in Civil Works Engineer Bulletin No. 52-8. It is assumed to be uniformly distributed over the Blackstone River watershed above the Woonsocket gage and amounts to 12.0 inches in 72 hours with a maximum 24-hour value of 9.6 inches and a maximum 6-hour value of 7.4 inches. After a review of stream gaging and precipitation records, the floods of July 1938, September 1954, and August 1955 were selected for unit hydrograph analyses. The adopted unit hydrograph, based on the analyses of the three floods, is shown on Plate No. A-3 in Appendix A.

The SPF for the Blackstone River at the Woonsocket gage was derived by applying the SPS rainfall excess to the adopted unit hydrograph. Similarly, standard project floods were developed for both the tributary Mill and Peters Rivers. The computed SPF discharge for the Blackstone River in Woonsocket amounts to 30,000 c.f.s. above the junction of the Mill and Peters Rivers and 34,500 c.f.s. below the junction of these tributaries. The computed SPF discharges for the Mill and Peters Rivers are 6,700 c.f.s. and 2,600 c.f.s., respectively. In adopting design discharges, consideration was given to the reduction in the Blackstone River standard project flood which would be afforded by the authorized West Hill Reservoir.

11. EXTENT AND CHARACTER OF THE FLOODED AREA

The City of Woonsocket, with a population of 50,211 (1950 census), is one of the major textile producing centers of New England. The economy of the city is based largely upon textiles. In recent years there has been an increase in the diversification of industry. Industrial activity in the city includes the manufacture of machinery, rubber goods, plastics, and electrical products. Some 50 textile plants are located along the natural water-courses of the Blackstone, Mill, and Peters Rivers within the city, utilizing a highly developed system of water-supply canals, highways, and two branch lines of the New York, New Haven and Hartford Railroad which connect directly with the main line between New York and Boston.

During the record flood of August 1955, the Blackstone, Mill, and Peters Rivers inundated an estimated 270 acres of the highly developed and thickly settled area of Lower Woonsocket, downstream from South Main Street. More than 300 buildings of all types were affected. Damages ranged from flooded and heavily silted basements to total destruction. Industrial concerns with plants located on low ground along the waterways were particularly hard hit. Over 20 industrial concerns, the majority producers of wool textiles, experienced severe losses. These industries have an average annual employment of some 2,800 workers, representing approximately 25 percent of Woonsocket's industrial employment, with an average annual payroll of more than 7 million dollars.

Severe flooding and a heavy concentration of damages occurred in the Social District on the left bank of the Blackstone River near the confluence of the Mill and Peters Rivers. Following the breach of Harris Pond dam, a powerful surge swept down the Mill River and cut a wide swath of destruction. This surge destroyed the Privilege and East School Street bridges and scoured out extensive sections of the bridge approaches, gouged new channels in several places, and deposited tons of silt and debris on the floors of mills and other buildings in its path. Commercial and residential damages were especially heavy in the heart of the Social District as a result of the combined flooding of the Blackstone, Mill, and Peters Rivers.

Throughout Lower Woonsocket public utilities, highways, and railroad lines were severely damaged, causing a complete and lengthy disruption of normal activities. In addition to the great physical damages caused by the flood, a serious menace to public health existed as a result of polluted floodwaters and heavy silting.

Prior to the record flood of August 1955, three floods of major proportions, those of November 1927, March 1936, and July 1938 occurred in Lower Woonsocket. Although stages caused by these floods were

approximately 7 feet below the flood crest of August 1955, damages were serious. Flooding in the Social District resulted in substantial residential and commercial losses. Damages sustained by the textile industries in Lower Woonsocket also accounted for a large part of the losses caused by these floods.

Like other New England textile manufacturing centers, Woonsocket has been affected by the decline in recent years of the textile economy in the Northeast. The general economy of the city has been bolstered somewhat by the movement of several new manufacturers of diversified products into the flood-free portions of the city. However, an important segment of the industrial and commercial center of Lower Woonsocket, with established railroad and highway facilities, is located in the flood area of the Blackstone and Mill Rivers. There is little doubt that possibilities for further development and utilization of existing available lands and buildings, which otherwise would be attractive to new industries, will remain unrealized under the threat flood repetition.

12. FLOOD DAMAGES

12.1 General.- Unprecedented devastation was caused in Lower Woonsocket by the record flood of August 1955. In the area downstream from South Main Street, including the area inundated by flooding of the Mill and Peters Rivers, 1955 losses amounted to over $12,300,000, representing about 57 percent of the losses in the city as a whole. This estimate of losses is based on the findings of a detailed flood-damage survey conducted immediately after the flood. A description of damage areas and a summary of losses by area and type are given in Table III.

It is estimated that a recurrence of the stages produced by the floods of 1927, 1936, and 1938, which were of approximately the same magnitude, under economic conditions existing in 1956, would cause losses in Woonsocket amounting to $4,400,000 in each instance. About 25 percent of these damages would occur in the Lower Woonsocket area, downstream from South Main Street bridge. A recurrence of the August 1955 flood in Lower Woonsocket would cause losses estimated at $10,200,000.

12.2 Type and distribution of losses.- The August 1955 flood struck heavily at industrial concerns in Lower Woonsocket. A loss of over $3,400,000, representing almost 30 percent of the loss in the area downstream from South Main Street, was sustained by a total of 23 companies. The swift current of flood waters was responsible for the great intensity of destruction in several areas, notably along

TABLE III

AUGUST 1955 FLOOD LOSSES BY AREA AND TYPE

LOWER WOONSOCKET, RHODE ISLAND
(Losses in $1,000)

DESCRIPTION OF AREAS

I Left Bank of Blackstone River from South Main Street to Hamlet Avenue Bridge

II Mill River from Harris Pond Dam to East School Street

III Right bank of Blackstone River from South Main Street to Hamlet Avenue Bridge

IV Both banks Blackstone River from Hamlet Avenue bridge to City Line

Area	Urban	Industrial	Utility	Highway	Railroad	Total
I	4,430.	400.	170.	710.	470.	6,180.
II	730.	2,290.	30.	390.	-	3,440.
III	-	410.	250.	390.	460.	1,510.
IV	70.	320.	10.	800.	-	1,200.
Total	5,230.	3,420.	460.	2,290.*	930.	12,330.

*Includes bridge losses of $1,800,000.

the Mill River below Harris Pond and along the left bank of the Blackstone River between South Main Street and Hamlet Avenue. Industrial losses were extremely heavy in the area above East School Street as the result of the devastating surge created on the Mill River when Harris Pond dam failed.

A number of textile mills located on the left bank of the Blackstone River sustained severe losses under the impact of swiftly flowing floodwaters which covered floors to a depth of 9 feet. In the Hamlet District on the right bank, the French Worsted Company and the Argonne Worsted Company experienced heavy losses.

Damage to residential and commercial properties in Lower Woonsocket amounted to over $5,200,000, representing over 40 percent of the total loss. Most of this urban damage occurred in the areas along the Mill River and the left bank of the Blackstone River, with a high concentration of destruction near the mouth of the Mill River in the heart of the Social District. Damages ranging from flooded and silted basements to total destruction were experienced by approximately 150 dwellings and 190 commercial establishments. Five 2-story dwellings on Social Street were demolished by 9 feet of swiftly flowing water. The extreme depth of flooding and extensive silting forced the evacuation and temporary condemnation of more than 100 tenement houses in the area. A serious health hazard was created by heavy deposits of muck and debris on the streets and in basements and first floors of the buildings.

Public utilities and transportation facilities throughout the area were totally disrupted. The Privilege and East School Street bridges were destroyed and the Hamlet Avenue bridge, one of the main links in the highway system, had to be condemned. Two other bridges sustained major damages and nine others minor damages. Power and communication facilities were also heavily damaged. Damage to bridges and highways, which included several severe washouts, amounted to over $2,200,000, representing about 20 percent of the total loss.

12.3 Average annual losses.- Recurring flood losses have been converted to an annual basis for the purpose of economic evaluation and comparison of benefits to costs. Estimates of annual losses have been derived in accordance with the standard practice of the Corps of Engineers of correlating stage-damage, stage-frequency, and damage-frequency relationships. Average annual losses remaining in Lower Woonsocket, after reductions which would be effected by the authorized West Hill Reservoir, amount to $215,000.

Appendix C, "Flood Losses and Benefits," contains detailed descriptions of damage surveys, analyses of damage, and derivation of annual losses and benefits.

13. EXISTING CORPS OF ENGINEERS FLOOD CONTROL PROJECTS

13.1 Existing projects.- The Flood Control Act of 1944 authorized four flood control projects in the Blackstone River Basin. These are the West Hill Reservoir on the West River in Massachusetts and three local protection projects for Worcester, Massachusetts, and Woonsocket and Pawtucket, Rhode Island. The Worcester and Pawtucket projects have no effect on flows and stages of the Blackstone River at Woonsocket.

13.2 West Hill Reservoir.- The West Hill dam site is on the West River in the Town of Uxbridge, Massachusetts, approximately 12.5 miles upstream from the center of Woonsocket. The project provides for 11,900 acre-feet of flood control storage, which is equivalent to 8.0 inches of runoff from its drainage area of 28 square miles. This drainage area represents 6.7 percent of the drainage area of 416 square miles at the U.S.G.S. gaging station in Woonsocket. The reservoir, currently in the planning stage, would effect a one-foot stage reduction in the standard project flood at Woonsocket. The total estimated cost of the project is $3,360,000 (1956 price level). Expenditures for engineering studies amount to $83,000 through 30 June 1956. The last approved estimate of the annual cost of maintenance and operation is $16,500 (1951).

13.3 Woonsocket Local Protection Project.- The existing project is immediately upstream from the area investigated for this report. It will provide protection for the area upstream from South Main Street bridge. This will be accomplished by deepening, widening, and straightening the Blackstone River channel from South Main Street bridge upstream for about 8,300 feet to a point near the Massachusetts-Rhode Island state line; by replacing the existing Woonsocket Falls Dam with a new dam with crest gates; and by constructing dikes, a floodwall, and a pumping station in an industrial area on the left bank near the upstream end of the project. This project will have negligible effect on flood flows and stages in the Lower Woonsocket area. The total estimated first cost is $5,769,000 (1956 price level); local cost is estimated at $769,000. The estimate for annual maintenance and operation is $20,000 (1956 price level). Construction was initiated in July 1956 and is scheduled for completion in 1959.

14. IMPROVEMENTS BY OTHER FEDERAL AND NON-FEDERAL AGENCIES

The authorized Woonsocket Local Protection project, discussed in paragraph 13.3, is the only Federal flood control project in Woonsocket. Non-Federal or private agencies have constructed no flood control improvements in Woonsocket. There are presently three dams on the main river

in Woonsocket and one on the tributary Peters River. Five other dams on the Mill River were destroyed by the flood of August 1955. The past and present use of these dams are discussed in paragraph 5.4.

Channel improvement studies made for this report found that removal of the two lower dams on the main river, Bernon Dam and Hamlet Dam, would be desirable for flood control purposes. Removal of a presently unused dam in Manville, located 3.5 miles downstream from Woonsocket, was also considered. Hydraulic studies indicated, however, that removal of this dam would have a negligible effect on flood stages in Woonsocket.

15. IMPROVEMENTS DESIRED

A public hearing was held at Woonsocket, Rhode Island on 26 November 1956. All interested parties were invited to attend the hearing and present their needs and views. Approximately 150 persons attended, including the Governor of Rhode Island, representatives of Congressmen in the area, state and local officials, manufacturers, businessmen, and representatives of local organized groups and the local utility company. A flood control plan under consideration by the Corps of Engineers was presented at the hearing. All speakers expressed strong support for the immediate construction of the improvements under consideration and, in addition, urged that the plan be modified to include protection for a larger area. Subsequent studies resulted in an expansion of this plan to include a dike and floodwall on the right bank of the Blackstone River in the Hamlet District area, and the removal of Hamlet Dam and channel excavation in the vicinity of the dam. The expanded plan is described in Section 17. A digest of the hearing record is contained in Appendix F.

16. FLOOD PROBLEMS AND SOLUTIONS CONSIDERED

16.1 Flood problem.- The Blackstone River is susceptible to floods caused by heavy rains or a combination of heavy rains and melting snow. Runoff is rapid owing to generally hilly topography and a thin soil cover which is not conducive to infiltration of heavy rainfalls for any appreciable time. Highly developed areas of Lower Woonsocket, consisting of industrial and commercial sites with congested residential developments, are located in the flood plain. A recurrence of the August 1955 flood in Lower Woonsocket, without flood protection, would cause an estimated loss of $10,200,000.

16.2 Solutions considered. Several practical methods of protecting Lower Woonsocket from damaging floods were considered. A preliminary analysis of possible solutions to the flood problem indicated that a

general channel improvement on the Blackstone River or reservoirs on the tributary Mill and Peters Rivers might provide a partial solution. Channel improvement on the Blackstone River and a reservoir on the Mill River proved to be uneconomical and would provide inadequate protection. A reservoir on the Peters River was discarded early in the studies, because it would effect negligible reductions in flood stages at Lower Woonsocket and at other downstream damage points. The reconstruction of Harris Pond dam on the Mill River at the city limits was also considered. However, analysis revealed that the former reservoir had a storage capacity of less than one inch of runoff and that no substantial increase in capacity could be effected due to extensive development in the area, thereby precluding its use for flood control purposes.

The most economical solution to the flood control problem, as it exists in the area concerned, is the construction of dikes and floodwalls with appurtenant works at two sub-areas and the removal of Hamlet and Bernon Dams with contiguous channel excavation. The entire plan is described in section 17. Dikes and floodwalls in other areas were found to be uneconomical. Combinations of the general channel improvement or the reservoir on the Mill River with dikes and floodwalls were also considered. However, since the channel improvement and the reservoir lacked economic justification when assigned a first priority of benefits, it was apparent that they would be unjustified as incremental units.

Except for the previously discussed reservoirs on the Mill and Peters Rivers, this interim report does not include studies of reservoirs in the Blackstone River Basin upstream from Woonsocket. An analysis of the authorized West Hill Reservoir indicated that additional upstream reservoirs would not materially affect the size of local protection works at Lower Woonsocket. Operation of the West Hill Dam and Reservoir would reduce the stage of a recurring August 1955 flood by one foot. A preliminary analysis revealed that any reservoirs that may be developed in the Blackstone River Basin above Woonsocket would control smaller drainage areas than the West Hill Reservoir and would effect smaller reductions. In the event that additional reservoirs are developed as a result of the authorized review of prior reports on the Blackstone River Basin, such reservoirs would serve to increase the degree of protection provided by local works.

The economically justified plan of dikes and floodwalls, dam removal, and appurtenant works is described further in the following paragraphs and in Appendix D. Additional information on other plans studied is contained in Appendix E.

17. FLOOD CONTROL PLAN

17.1 Lower Woonsocket Local Protection Project.- Improvements considered most desirable for Lower Woonsocket are divided into three independent flood protection units referred to separately as the "Social District Unit," the "Hamlet District Unit", and the "Bernon Unit". The Social District unit is comprised of dikes and floodwalls on the left bank of the Blackstone River, pressure conduits and other improvements along the lower reaches of the tributary Mill and Peters Rivers, and removal of Hamlet Dam with contiguous channel excavation. The Hamlet District Unit would provide for a dike and floodwall on the right bank of the Blackstone River. The Bernon Unit is comprised of the removal of Bernon Dam and channel improvement immediately upstream and downstream thereof.

17.1.1 Social District Unit.- The Social District Unit would provide for 2,550 feet of earth dike and concrete floodwall along the left bank of the Blackstone River. Hamlet Dam would be removed and the river channel would be excavated for about 1,300 feet adjacent to the dike and floodwall. The confinement and discharge of Mill River flood flows would be accomplished by the improvement of 2,740 feet of Mill River channel, supplemented by the construction of 2,900 feet of earth dike and 1,050 feet of twin-barreled pressure conduit. Similarly, the construction of 900 feet of earth dike and concrete floodwall and 1,200 feet of pressure conduit would serve to confine and discharge flood flows of the Peters River. Interior drainage would be handled by a pumping station.

Construction of the Social District Unit would involve the acquisition of 7 sets of buildings. Alteration of utilities would be required at five points where a conduit would cross an existing street. Removal of Hamlet Dam would necessitate the modification of existing water pumping facilities at three textile plants. A cost estimate of the principal features of this unit is presented in Table IV. Appendix D contains drawings and more detailed information on cost estimates and project features.

17.1.2 Hamlet District Unit.- This unit would consist of 3,000 feet of earth dike with a short section of concrete floodwall along the right bank of the Blackstone River. A pumping station would discharge interior drainage.

Construction of the Hamlet District Unit would involve the acquisition of 1 set of buildings and the relocation of a short section of unpaved access road. A cost estimate of the principal features is given in Table V. See Appendix D for drawings and more detailed information on estimates and project features.

17.1.3 Bernon Unit.- This unit would provide for the removal of Bernon Dam and the excavation of 600 feet of Blackstone River channel in the vicinity of the dam.

Construction of the Bernon Unit would involve the acquisition of Bernon Dam and appurtenant facilities and the underpinning of Bernon Street bridge. A cost estimate of the principal features of this unit is presented in Table VI. Appendix D contains drawings and more detailed information on cost estimates and project features.

17.2 Design flood.- The Social District and the Hamlet District Units are designed to protect against a flood stage equal to that of the standard project flood modified by operation of the authorized West Hill Reservoir. The Bernon Unit, a channel improvement upstream from the Social and Hamlet District Units, would reduce the stage of a flood of August 1955 magnitude by about 4-1/2 feet upstream from the dam. In the event that Harris Pond dam is reconstructed on the Mill River immediately upstream from the project area, it was assumed that adequate design of the new dam would preclude a recurrence of the August 1955 failure. The estimated discharge of the standard project flood at the U.S.G.S. gaging station on the Blackstone River in Woonsocket is 34,500 c.f.s. under natural conditions, and 31,900 c.f.s. after modification by West Hill Reservoir. Upstream from the Mill River confluence, the natural and modified flows of the Blackstone River standard project flood are 30,000 c.f.s. and 27,800 c.f.s., respectively. The estimated standard project flood discharge is 6,700 c.f.s. for the Mill River and 2,600 c.f.s. for the Peters River. The top elevation of dikes and floodwalls provide for a minimum of three feet of freeboard above design flood stage. The derivation of the standard project flood and hydraulic design criteria are presented in Appendix A, "Hydrology and Hydraulic Analysis."

18. MULTIPLE-PURPOSE FEATURES

The Lower Woonsocket Local Protection Project is designed solely for flood protection and contains no multiple-purpose features.

19. RECREATIONAL DEVELOPMENT

The components of the project are unsuitable for recreational development.

20. ESTIMATES OF FIRST COST AND ANNUAL CHARGES

The total estimated first cost of the Lower Woonsocket Local Protection Project is $4,255,000 exclusive of the cost of water rights at Bernon Dam. Resulting annual charges are estimated at $167,800. First costs to the United States and to local interests are $2,970,000 and $1,285,000, respectively. Federal annual charges amount to $107,000, and non-Federal to $60,800. Cost estimates do not include an allowance for the value of water rights at Bernon Dam, which is owned by the Blackstone Valley Gas and Electric Company. Representatives of the company have informally indicated that the generating facilities are old, that the installation furnishes less than one percent of the city's power requirements, and that they would offer no opposition to removal of the dam. The cost of the water rights would not alter Federal costs and is not expected to materially affect project economics.

Estimates have been prepared on the basis that local interests would bear the entire cost of relocations, furnish all lands and rights-of-way necessary for construction and operation of the project and, in addition, make a cash contribution of part of the construction cost owing to enhancement and higher utilization benefits accruing to the project. Local interests would be required to maintain and operate the project after completion.

Unit prices used in estimating costs are based on average bid prices for similar work in the same general region. The adopted unit prices are adjusted to the 1956 price level and include minor items of work which do not appear in the cost estimates. Annual charges are based on an annual interest rate of 2.5 percent, with amortization of the project cost distributed over a 50-year period. A summary of first costs and annual charges is given in Tables IV through VII. A detailed presentation of costs and annual charges, including the basis of estimates and the allocation of costs to local interests, is set forth in Appendix D.

TABLE IV

SUMMARY OF FIRST COSTS
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
SOCIAL DISTRICT UNIT

Lands, Damages, and Relocations		
Lands & Damages	$275,000	
Relocations	285,000	
Total Lands, Damages, and Relocations		$ 560,000
Construction		
Channels	$460,000	
Dikes & Floodwalls	1,690,000	
Pumping Station	260,000	
Engineering & Design	240,000	
Supervision & Administration	190,000	
Total Construction		$2,840,000
TOTAL FIRST COSTS		$3,400,000

	Federal First Cost	Non-Federal First Cost	Total
Lands, Damages, and Relocations	-	$ 560,000	$ 560,000
Construction	$2,400,000	440,000	2,840,000
Total	$2,400,000	$1,000,000	$3,400,000

TABLE V

SUMMARY OF FIRST COSTS
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
HAMLET DISTRICT UNIT

Lands, Damages, and Relocations		
Lands & Damages	$ 70,000	
Relocations	50,000	
Total Lands, Damages, and Relocations		$120,000
Construction		
Dike & Floodwall	$250,000	
Pumping Station	240,000	
Engineering & Design	50,000	
Supervision & Administration	40,000	
Total Construction		$580,000
TOTAL FIRST COSTS		$700,000

	Federal First Cost	Non-Federal First Cost	Total
Lands, Damages, and Relocations	-	$120,000	$120,000
Construction	$450,000	130,000	580,000
Total	$450,000	$250,000	$700,000

TABLE VI

SUMMARY OF FIRST COSTS*
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
BERNON UNIT

Lands, Damages, and Relocations		
Lands & Damages	$ 14,000	
Relocations	21,000	
Total Lands, Damages, and Relocations		$ 35,000
Construction		
Channel	$100,000	
Engineering & Design	12,000	
Supervision & Administration	8,000	
Total Construction		$120,000
TOTAL FIRST COSTS		$155,000

	Federal First Cost	Non-Federal First Cost	Total
Lands, Damages, and Relocations	-	$ 35,000	$ 35,000
Construction	$120,000	-	120,000
Total	$120,000	$ 35,000	$155,000

*Does not include the cost of water rights at Bernon Dam

TABLE VII

SUMMARY OF ANNUAL CHARGES
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT

	Social District Unit	Hamlet District Unit	Bernon Unit	Total
Federal Annual Charges				
Interest	$ 61,500	$ 11,400	$3,000	$ 75,900
Amortization	25,200	4,700	1,200	31,100
Total Federal Annual Charges	$ 86,700	$ 16,100	$4,200	$107,000
Non-Federal Annual Charges				
Interest	$ 25,600	$ 6,300	$ 900	$ 32,800
Amortization	10,500	2,600	400	13,500
Maintenance and Operation	5,800	2,900	100	8,800
Interim replacements	1,900	1,700	-	3,600
Net loss of taxes	1,500	400	200	2,100
Total Non-Federal Annual Charges	$ 45,300	$ 13,900	$1,600	$ 60,800
TOTAL ANNUAL CHARGES	$132,000	$ 30,000	$5,800	$167,800

21. ESTIMATES OF BENEFITS

21.1 Flood-prevention benefits.- The Lower Woonsocket Local Protection Project would provide protection for the Social District and part of the Hamlet District of Lower Woonsocket against a standard project flood modified by operation of the authorized West Hill Reservoir. It would also provide partial protection for properties along both banks of the Blackstone River between Hamlet Dam and South Main Street bridge. The record flood of August 1955 produced stages approximately one foot below the estimated stages of the standard project flood under natural conditions. Without flood protection, a recurrence of the August 1955 flood would cause losses of $10,200,000 in Lower Woonsocket. Operation of West Hill Reservoir would reduce these recurring losses to $7,150,000. The Lower Woonsocket Local Protection Project would prevent an estimated $6,140,000 of this remaining loss, with $4,900,000 attributable to the Social District Unit, $1,100,000 to the Hamlet District Unit, and $140,000 to the Bernon Unit. Residual losses of $1,010,000 would occur principally along the Blackstone River between Bernon Street bridge and the New York, New Haven and Hartford Railroad bridge and along the left bank downstream from Hamlet Avenue bridge. Protection to eliminate these residual losses would require extensive local protection works which lack economic justification.

For the purpose of economic analyses, recurring losses have been converted to annual losses according to the standard practice of the Corps of Engineers. Annual flood-prevention benefits were derived for the reaches downstream from South Main Street by determining the difference between annual losses which would remain after discharge reductions effected by the authorized West Hill Dam and Reservoir and those which would remain after supplementation by construction of the Lower Woonsocket Project.

Annual flood prevention benefits for the Lower Woonsocket Project, under economic conditions existing in 1956, would amount to $140,000. Of this total, annual benefits of $114,000 would be realized by the Social District Unit, $17,000 by the Hamlet District Unit, and $9,000 by the Bernon Unit. The derivation of annual flood losses and flood prevention benefits is discussed further in Appendix C, "Flood Losses and Benefits."

21.2 Enhancement benefits.- A survey of economic conditions and an analysis of flood losses and benefits were made in the areas of Lower Woonsocket considered for flood protection, in order to determine the extent of enhancement or higher utilization of lands and buildings which could be expected as a result of project construction. This analysis revealed that substantial development of lands currently idle

and higher utilization of vacant industrial and commercial space can be expected to follow the construction of the Lower Woonsocket Local Protection Project. The value of this enhancement would be an additional benefit to the project.

A study of past, present, and future use of idle lands and vacant industrial and commercial space was made to obtain sufficient data for a sound economic analysis of potential annual enhancement. Valuable information was obtained from various responsible sources such as city officials, bankers, real estate brokers, industrial managers, and representatives of the Chamber of Commerce, the Industrial Development Foundation of Greater Woonsocket, and the Retail Trade Board.

The investigation revealed that a specific potential exists for enhancement and higher utilization of industrial and commercial space and lands in the project protection areas of Lower Woonsocket. Available evidence indicates, however, that no enhancement of lands or buildings would be realized in the protection area of the Bernon Unit. The following summary presents the estimated annual enhancement benefits in the Social and Hamlet Districts. Appendix C contains additional data and a more detailed description of the derivation of these benefits.

SUMMARY OF ANNUAL ENHANCEMENT AND HIGHER UTILIZATION BENEFITS

(1956 Price Level)

Type of Enhancement or Higher Utilization	Social District Unit	Hamlet District Unit	Total Benefits
Lands	$50,300	$ -	$50,300
Industrial Space	11,000	23,000	34,000
Commercial Space	10,700	-	10,700
Total	$72,000	$23,000	$95,000

21.3 Collateral benefits.- The Lower Woonsocket Local Protection Project would realize no benefits to fish and wildlife, recreation, pollution abatement, or other collateral purposes.

21.4 Intangible benefits.- Significant intangible benefits to the general welfare and security of the people, which cannot be measured in monetary terms, would be realized from the construction of the Lower Woonsocket Local Protection Project. The economy and welfare of Woonsocket as a whole would benefit directly from revitalization of industry and commerce in the affected area. In addition to reduction in the potential threat of loss of life and physical injury to residents

in the flood area of Lower Woonsocket, construction of the recommended project would minimize, if not remove altogether, many of the dangers accompanying a general flood, such as the widespread menace of polluted and disease-bearing floodwaters and hazards attendant upon emergency evacuation of whole areas.

21.5 Summary of benefits.- The estimated annual benefits for the Lower Woonsocket Local Protection Project, computed as incremental to those assigned to the operation of West Hill Reservoir, amount to $235,000 at the 1956 price level. The following summary sets forth the annual benefits by type and unit for the Lower Woonsocket Local Protection Project.

SUMMARY OF ANNUAL BENEFITS

	Flood Damage Prevention Benefits	Enhancement Benefits	Total Benefits
Social District Unit	$114,000	$72,000	$186,000
Hamlet District Unit	17,000	23,000	40,000
Bernon Unit	9,000	-	9,000
Total Lower Woonsocket Local Protection Project	$140,000	$95,000	$235,000

22. COMPARISON OF BENEFITS TO COSTS

Average annual benefits for the Lower Woonsocket Local Protection Project are estimated at $235,000. Average annual costs are estimated at $167,800 based on first costs exclusive of water rights at Bernon Dam. The resulting ratio of benefits to costs is 1.4 to 1.0. The cost of Bernon Dam water rights, an item of local responsibility, is not expected to materially affect project economics. The breakdown of benefits and costs between the three units of the project is as follows:

	Annual Benefits	Annual Costs	Benefit-Cost Ratio
Social District Unit	$186,000	$132,000	1.41 to 1.0
Hamlet District Unit	40,000	30,000	1.33 to 1.0
Bernon Unit	9,000	5,800	1.55 to 1.0
Total Lower Woonsocket Local Protection Project	$235,000	$167,800	1.4 to 1.0

23. LOCAL COOPERATION

In accordance with Section 3 of the Flood Control Act of 1936, local interests would be required to provide without cost to the United States, all lands, easements, and rights-of-way necessary for the construction and operation of the project; hold and save the United States free from damages due to the construction works; and maintain and operate all the works after completion in accordance with regulations prescribed by the Secretary of the Army. The responsiblity for the relocation or modification of highway facilities and utilities would rest with local interests under the requirements of lands, easements, and rights-of-way.

Local interests would also be required to contribute to the United States approximately 16.1 percent of the construction costs owing to enhancement benefits to be realized by the project. This contribution is presently estimated at $570,000 (1956 price level). An analysis of funds to be contributed by local interests is set forth in Appendix D.

There is an intense desire for flood protection in Woonsocket. City officials have indicated a willingness to fulfill the conditions of local cooperation. The City of Woonsocket and the State of Rhode Island are currently sharing local costs for the existing project, and the required bond issues to finance these costs were authorized at general elections.

24. COORDINATION WITH OTHER AGENCIES

Plans for the protective works in the Lower Woonsocket area have been reviewed by representatives of the State of Rhode Island and the City of Woonsocket. Representatives of the Federal Bureau of Public Roads have reviewed the flood control plan in conjunction with relocation of Hamlet Avenue bridge across the Blackstone River in the project area. Relocation of the bridge, which is not a component of the Lower Woonsocket Local Protection Project, will be accomplished by the State of Rhode Island. The City of Woonsocket plans to construct two other bridges to replace existing temporary crossings on the Mill River in the project area. The design of the new structures will be coordinated with the requirements of protective works in Lower Woonsocket. The project has no effect on fish and wildlife, recreation, pollution abatement, or other collateral purposes. Letters from the Governor of the State of Rhode Island and the Mayor of Woonsocket indorsing the project are included in Appendix F. A letter of comment from the Regional Director of the Fish and Wildlife Service is also included.

25. DISCUSSION

25.1 Flood problem.- Flood protection for the Lower Woonsocket area is urgently needed. Many industrial and commercial establishments and congested residential developments are located in the flood plain. Four major floods have occurred in the last 30 years, causing widespread damage and disruption of the Woonsocket economy. The record flood of August 1955 caused damages of $12,300,000 in Lower Woonsocket; extensive evacuation was necessary to prevent loss of life. Without flood protection, recurrence of the August 1955 flood would produce losses of $10,200,000 in Lower Woonsocket.

25.2 Solutions considered.- Several practical methods of protecting Lower Woonsocket from damaging floods were considered. These methods include channel improvement, reservoirs on the tributary Mill and Peters Rivers, dikes and floodwalls, and combinations of channel improvement or reservoir with dikes and floodwalls.

25.3 Selection of plan.- The most desirable plan for flood protection in Lower Woonsocket is the construction of the Lower Woonsocket Local Protection Project, consisting of dikes and floodwalls on the left bank of the Blackstone River in the Social District, dikes and floodwalls on the right bank in the Hamlet District, and the removal of Bernon Dam, on the Blackstone River, including contiguous channel excavation near the upstream limit of the Lower Woonsocket area. The Social District protective works would include pressure conduits and other improvements along the Mill and Peters Rivers, to prevent flooding behind the main river dike and floodwall and to provide for tributary discharge through the floodwall. The removal of Hamlet Dam on the Blackstone River and channel excavation in the vicinity of the dam would also be part of the Social District works. City officials and local groups have concurred in the construction of this project and public sentiment is strongly in favor of early completion.

The construction of dikes and floodwalls in addition to those contained in the Lower Woonsocket Local Protection Project would be economically unjustified at this time. These additional improvements would be located principally along the Blackstone River between South Main Street bridge and the New York, New Haven and Hartford Railroad bridge, and along the left bank downstream from Hamlet Avenue bridge. A general channel improvement on the Blackstone River and a reservoir on the tributary Mill River were found to lack economic justification, either as individual units or as incremental units in a plan containing dikes and floodwalls. In addition to being uneconomical, the channel

improvement and the reservoir would provide inadequate protection, except when combined with dikes and floodwalls. A reservoir on the Peters River would effect negligible reductions in flood stages at Woonsocket and other downstream damage points.

Except for the reservoirs on the Mill and Peters Rivers, this interim report does not include studies of reservoirs upstream from Woonsocket. An analysis of the authorized West Hill Reservoir indicated that it would reduce recurring 1955 flood stages at Woonsocket by one foot. A preliminary analysis of the basin revealed that any additional reservoirs would control smaller drainage areas than West Hill and would effect lesser reductions at Woonsocket. In the event that additional reservoirs are developed as a result of review studies for the Blackstone River Basin, such reservoirs would serve to increase the degree of protection provided by local protection works. The monetary benefits for additional reservoirs would be derived substantially from flood reductions at locations other than Woonsocket.

25.4 Costs and benefits.- The total estimated first cost of the Lower Woonsocket Local Protection Project is $4,255,000 excluding the cost of water rights at Bernon Dam. Resulting annual charges are estimated at $167,800. The cost of the water rights, an item of local responsibility, is not expected to materially affect project economics and would have no bearing on Federal costs. Annual benefits attributable to construction of the project are estimated at $235,000. The ratio of benefits to costs is 1.4 to 1.0. In a recurrence of the August 1955 flood, the project would prevent losses of $6,140,000 in addition to those preventable by operation of the authorized West Hill Reservoir.

26. CONCLUSIONS

It is concluded that the Blackstone River produces major flood damages in Woonsocket, Rhode Island, in the area downstream from the existing Woonsocket Local Protection Project. The Lower Woonsocket area faces the continuing threat of heavy damages in the future, and protection can be provided most suitably by construction of the Lower Woonsocket Local Protection Project at a total estimated first cost of $4,255,000 plus the cost of water rights at Bernon Dam. This plan would afford a high degree of protection and is economically justified. The ratio of annual benefits to annual costs is 1.4 to 1.0. The frequency of major floods and the existing high concentration of industrial, commercial, and residential developments make immediate construction of the project imperative.

27. RECOMMENDATIONS

It is recommended that the plan for the control of floods in the Blackstone River Basin, as contained in the Flood Control Act approved December 22, 1944 (Public Law No. 534, 78th Congress), be modified to provide for the construction of a local protection project on the Blackstone, Mill, and Peters Rivers in the Social District, the Hamlet District, and the Bernon Dam area of Woonsocket, Rhode Island, subject to the conditions that local interests be required to (a) contribute to the United States approximately 16.1 percent of the construction cost, representing the degree of enhancement benefits, which contribution is presently estimated at $570,000; (b) furnish all lands, easements, and rights-of-way necessary for the construction and operation of the project; (c) hold and save the United States free from damages due to the construction works; and (d) maintain and operate all the works after completion. The estimated first cost of these measures of local cooperation is $1,285,000. The total estimated project cost is $4,255,000, and the Federal cost is $2,970,000. The cost of water rights at Bernon Dam, an item of local responsibility, represents an expense in addition to the above estimated costs.

ALDEN K. SIBLEY
Brigadier General, U.S. Army
Division Engineer

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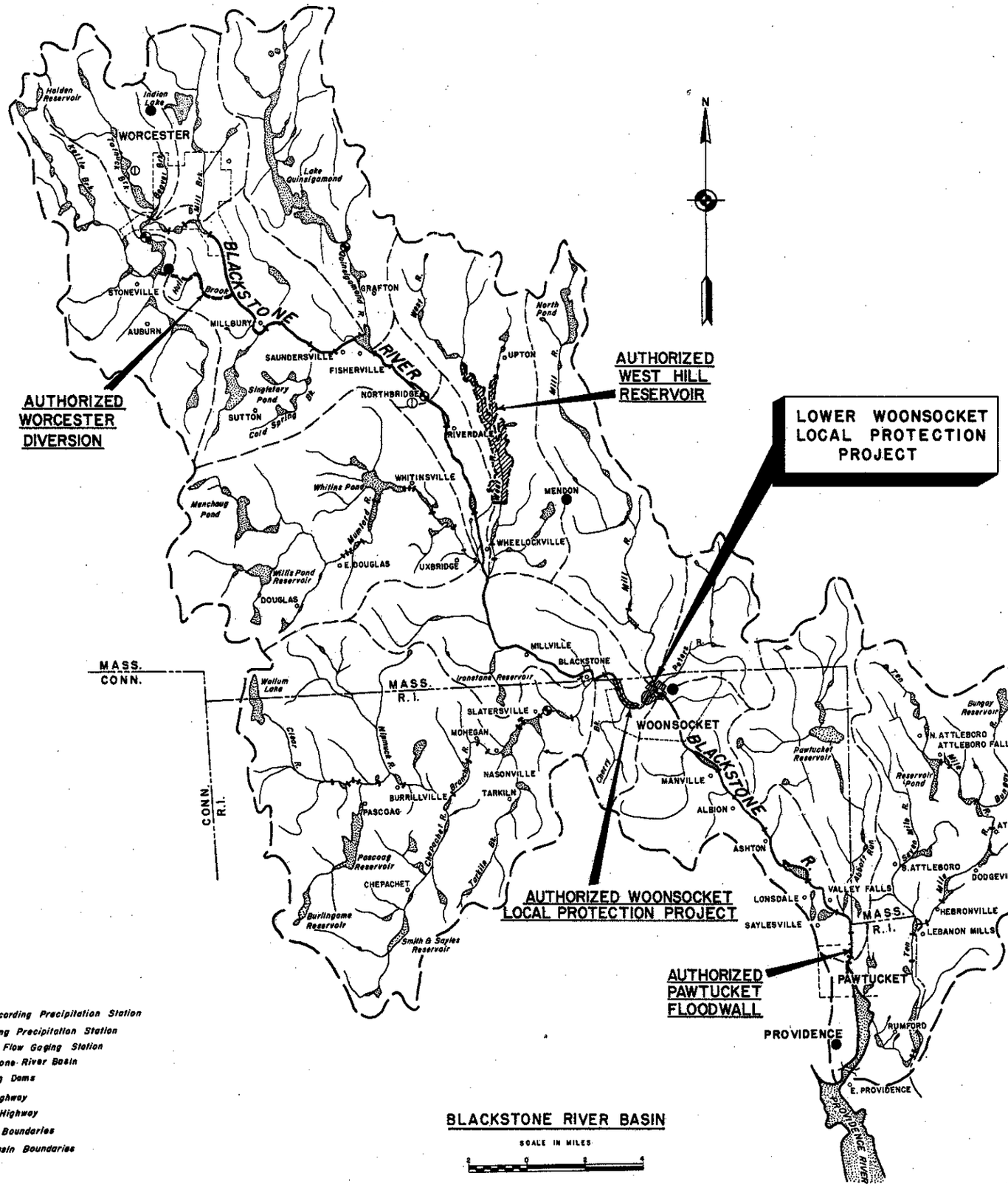


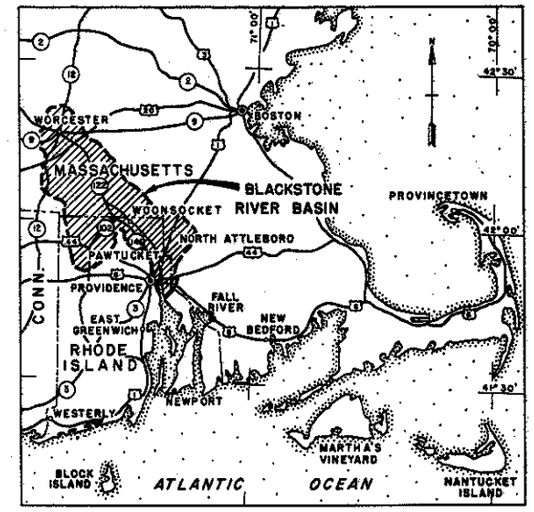
BLACKSTONE RIVER BASIN

SCALE IN MILES

0 5

LEGEND

- Non Recording Precipitation Station
- Recording Precipitation Station
- Stream Flow Gaging Station
- Blackstone River Basin
- Existing Dams
- U. S. Highway
- State Highway
- State Boundaries
- Sub-basin Boundaries



LOCATION MAP

SCALE IN MILES

15 0 15 30

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BOSTON, MASS.

DR. BY	TR. BY	CK. BY
R.W.C.	R.S.C.	

PROJECT ENGINEER
CHIEF HYD. & HYD. SECTION
SUBMITTED BY
CHIEF PLANS BRANCH
APPROVED
CHIEF ENGINEERING DIV
APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
BASIN MAP
BLACKSTONE RIVER, RHODE ISLAND
DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE AS SHOWN
DRAWING NUMBER
BE-1-1169
SHEET 1 OF 1

PLATE NO. 1

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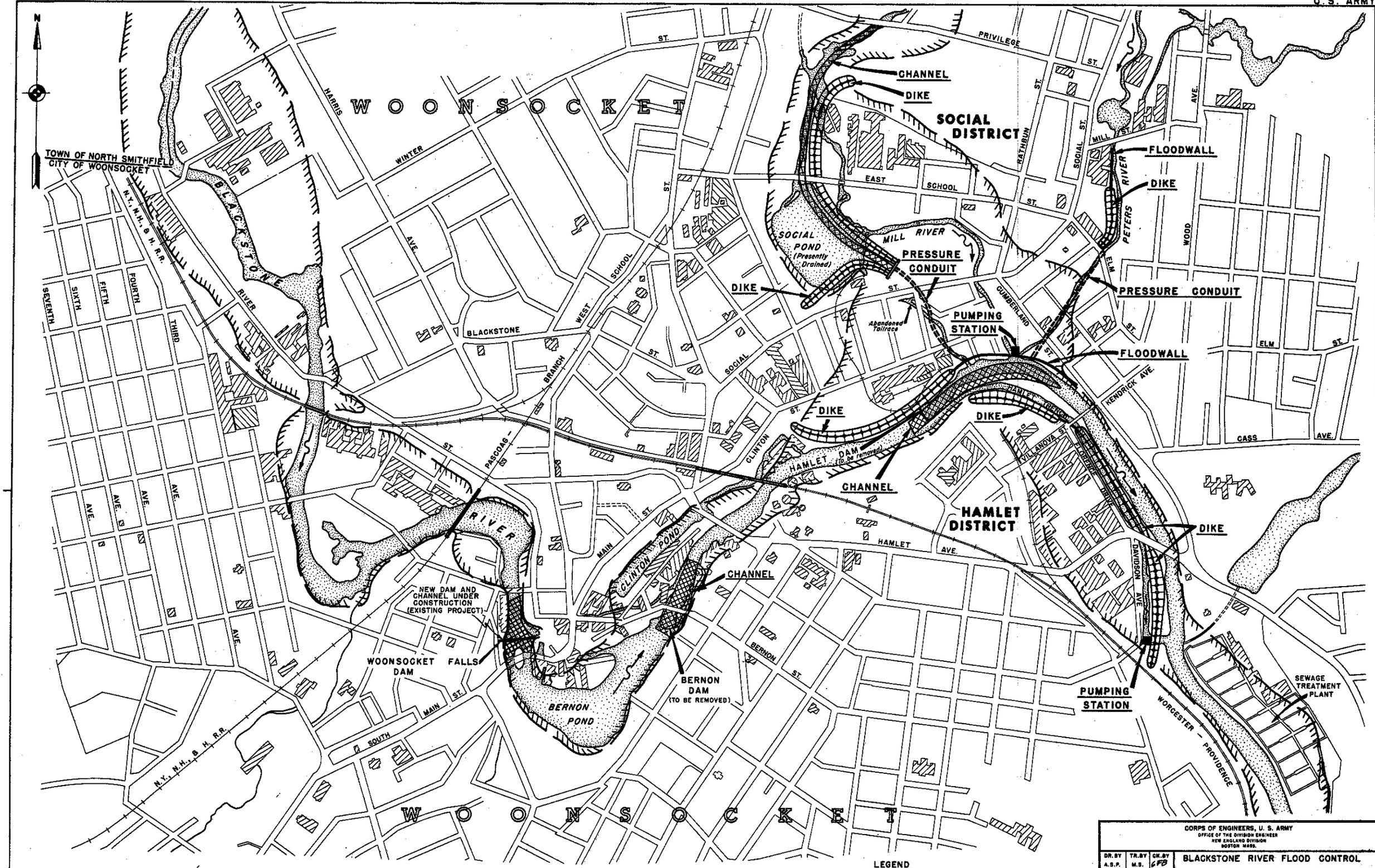

PLAN

SCALE IN FEET

300' 0 300' 600'

LEGEND

Approximate Limits of August 1955 Flood

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BOSTON MASS.

DR. BY	TR. BY	CK. BY
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PROJECT ENGINEER

SUBMITTED BY:

CHIEF, ENGR. DIV. or BRANCH

APPROVED BY:

CHIEF ENGINEERING DIV.

APPROVED

LT. COL. C.E. ASST TO DIVISION ENGINEER

DATE FEB. 1957

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
PROJECT PLAN
BLACKSTONE, MILL & PETERS RIVERS, RHODE ISLAND

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE AS SHOWN

DRAWING NUMBER
BE-1-1170

SHEET 1 OF 1

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PLATE NO. 2

APPENDIX A

HYDROLOGY AND HYDRAULIC ANALYSIS

APPENDIX A

HYDROLOGY AND HYDRAULIC ANALYSIS

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TABLES

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APPENDIX A

HYDROLOGY AND HYDRAULIC ANALYSIS

A1. CLIMATOLOGY

A1.1 General.- The Blackstone River Basin has a humid, continental climate, modified by the effects of the Atlantic Ocean. Variable weather conditions within the seasonal regimen are common. The range of average monthly temperatures between the warmest and coldest months is 45°F. Average annual precipitation in the basin amounts to approximately 45 inches, uniformly distributed throughout the year.

The basin lies in the paths of the "prevailing westerlies" and is exposed to the cyclonic disturbances that cross the country from the west and southwest toward the east and northeast. The area is also subject to storms that travel up the Atlantic Coast in either the form of hurricanes of tropical origin or storms of extra-tropical origin, called "northeasters." Although these coastal storms are heavily laden with moisture from the ocean, orographic influence on their rainfall patterns is slight, because there are no extremely high elevations within the watershed. Thunderstorms, either of local origin or associated with a frontal system, occur generally during the summer months. The locations of climatological stations in the basin are shown on Plate No. 1.

A1.2 Temperature.- The average annual temperature of the Blackstone River Basin is 49°F. Average monthly temperatures range between 71°F. and 73°F. in July and August to 25°F. and 29°F. in January and February. Extremes in temperature range from occasional highs slightly in excess of 100°F. to infrequent lows in the minus "twenties," particularly in the northern portions of the basin. A record of temperatures has been maintained at Worcester, Massachusetts, for the past 63 years and at Providence, Rhode Island, for 51 years. The mean, maximum, and minimum monthly temperatures recorded at these two stations for the period of record through 1955 are set forth in Table A-I.

A1.3 Precipitation.- The mean annual precipitation over the basin is about 45 inches uniformly distributed throughout the year. This average is based on a preliminary study of New England rainfall made in 1952 by the U.S. Weather Bureau. The range between maximum and minimum values of average monthly rainfall at any one station is no greater than 1 to 2 inches. Average monthly rainfalls at Providence range from a minimum of 2.09 inches in July to a maximum of 3.80 inches in August, and at Worcester from 3.19 inches in February to 4.06 inches in August. Precipitation records for Worcester, Massachusetts, and Providence, Rhode Island, for the period of record including 1955 are summarized in Table A-II.

TABLE A-I

MONTHLY TEMPERATURES
(Degrees Fahrenheit)

	Worcester, Mass.			Providence, R.I.		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	25.5	69	-17	29.9	68	- 9
February	25.4	66	-24	29.4	69	-17
March	35.0	84	- 6	37.9	90	2
April	45.7	91	8	47.6	91	11
May	57.2	92	27	52.0	95	32
June	66.0	96	33	67.0	101	39
July	71.0	102	41	72.9	101	49
August	68.9	99	35	71.0	102	44
September	62.0	100	26	64.0	99	33
October	51.8	89	13	54.2	90	25
November	40.1	81	3	43.3	82	9
December	28.5	67	-17	32.8	68	-12
Annual	48.1	102	-24	50.6	102	-17

TABLE A-II

MONTHLY PRECIPITATION
(Inches)

Station	Worcester, Mass.			Providence, R.I.		
Years of Record	102			51		
Elevation (ft., m.s.l.)	625			55		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	3.55	9.03	0.70	3.64	7.12	0.78
February	3.19	8.09	0.67	3.08	5.80	1.18
March	3.87	11.13	0.04	3.60	8.31	0.07
April	3.61	8.87	0.51	3.45	6.70	0.72
May	3.77	7.38	0.88	3.12	9.25	0.57
June	3.39	8.31	0.66	2.95	7.21	0.04
July	3.61	11.41	0.62	2.09	6.92	0.24
August	4.06	18.58	0.35	3.80	12.24	0.78
September	3.53	10.82	0.20	3.19	9.79	0.48
October	3.62	E10.79	0.36	2.93	7.00	0.15
November	3.77	9.82	0.66	3.55	8.50	0.31
December	3.50	7.77	0.78	3.50	9.44	0.58
Annual	43.47	61.71	27.92	39.88	58.57	29.50

E - Estimated

A1.4 Snowfall.- About one third of the precipitation during the winter months is in the form of snow. The annual basin snowfall averages from 35 to 40 inches, with extremes ranging from 30 inches in the southern portions to about 60 inches at northern inland points. The water content of the snow cover over the entire basin in the late winter or early spring seldom amounts to more than 1 or 2 inches. On rare occasions water content will amount to over 3 inches at interior locations. Data on snowfall at Worcester, Massachusetts, and Providence, Rhode Island, is presented below.

AVERAGE ANNUAL SNOWFALL

Station	Elevation (ft., m.s.l.)	Years of Record	Average Annual Snowfall
Worcester, Mass.	625	37 +	56
Providence, R.I.	55	49 +	33

A2. RUNOFF

A2.1 Discharge records.- Five U.S. Geological Survey gaging stations in the Blackstone River Basin are indicated on Plate No. 1 in the main report. Blackstone River discharges have been recorded at the U.S.G.S. gaging station in Woonsocket since March 1929. Hydrographs for this gage during the period of record through September 1955 are shown on Plate No. A-1.

A2.2 Stream-flow data.- Discharge in the Blackstone River Basin is measured at U.S. Geological Survey gaging stations on the Blackstone River and its principal tributaries. Flow data applicable to the area of the local protection project along the Blackstone River was obtained from Woonsocket gaging station records. There are no known stream-flow measurements or discharge records for the tributary Mill or Peters Rivers. The annual runoff at the Woonsocket gage for the 27 years of record through September 1955 varies from 37.06 inches to 10.62 inches with a mean of 23.00 inches. The mean annual runoff represents approximately 50 percent of the mean annual precipitation. Table A-III is a summary of the mean, maximum, and minimum monthly runoff in inches for the Blackstone River at the Woonsocket gaging station.

TABLE A-III

MONTHLY RUNOFF
(Inches)

BLACKSTONE RIVER AT WOONSOCKET, R.I.

Mar. 1929 - Sept. 1955

Month	Mean	Maximum	Minimum
January	2.31	4.46	0.58
February	2.17	4.40	0.92
March	4.07	11.24	2.03
April	3.48	6.76	1.67
May	2.29	4.02	0.79
June	1.52	4.15	0.38
July	0.91	6.79	0.26
August	0.91	7.45	0.27
September	1.00	5.29	0.23
October	0.82	2.46	0.28
November	1.43	4.61	0.34
December	2.05	5.05	0.47
Annual	23.00	37.06	10.62

A3. HISTORY OF FLOODS

A3.1 General.- Floods on the Blackstone River have occurred in all seasons of the year. Early spring rains combined with melting snow resulted in the flood of March 1936. Heavy rains during summer and fall months resulted in the record flood of August 1955, major floods in July 1938 and November 1927, and other floods in September 1954 and October 1955.

A3.2 Floods of record.- The flood of August 1955, the greatest flood of record on the Blackstone River, was about twice the magnitude of the previous record discharge. This flood resulted from record rainfall which accompanied "Hurricane Diane" and fell on ground saturated a few days earlier by the precipitation of "Hurricane Connie."

In July 1938, March 1936, and November 1927, the Blackstone River experienced three major floods of approximately the same magnitude. Floods of lesser magnitude occurred in September 1954 and October 1955. Table A-IV summarizes the largest floods on the Blackstone River recorded at the U.S. Geological Survey gaging station at Woonsocket.

TABLE A-IV

SUMMARY OF LARGEST EXPERIENCED FLOODS

BLACKSTONE RIVER AT WOONSOCKET GAGE

Date	Discharge (c.f.s.)
August 1955	32,900*
July 1938	15,100
March 1936	15,000
November 1927	15,000**
September 1954	9,400
October 1955	8,700

*Abnormal peak resulting from failure of Harris Pond Dam on Mill River. Natural peak discharge is estimated at 29,600 c.f.s.
**Estimated from flood marks.

A4. FREQUENCY OF FLOODS

The frequency of peak discharges on the Blackstone, Mill, and Peters Rivers was determined from records of the U. S. Geological Survey gaging station in Woonsocket. The frequency analysis was made in accordance with procedures described in Civil Works Engineer Bulletins 51-1 and 51-14, which are predicated on the assumption that the logarithmic values of annual peak flow are normally distributed. During high flows on the Blackstone River, a backwater condition occurs which results in high stages in the lower reaches of the Mill River. In view of this, the discharge-frequency data on both the Blackstone and Mill Rivers were related to stage, and a composite stage-frequency curve was developed for the lower reaches of the Mill River. These curves are shown on Plate No. A-2.

A5. DERIVATION OF STANDARD PROJECT FLOOD

A5.1 General.- The standard project flood (SPF) derived for the Blackstone River at Woonsocket will be equalled or exceeded only on rare occasions. The SPF was developed from standard project storm (SPS) rainfall and an adopted unit hydrograph.

A5.2 Standard project storm rainfall.- The standard project storm (SPS) rainfall was based on criteria described in Civil Works Engineer Bulletin No. 52-8. The SPS rainfall, assumed uniformly distributed

over the Blackstone River watershed above the Woonsocket gage (D.A. - 416 sq.mi.), amounts to 12.0 inches in 72 hours with a maximum 24-hour value of 9.6 inches and a maximum 6-hour value of 7.4 inches. Losses from infiltration, surface detention, transpiration, and other factors were assumed at a rate of 0.42 inches for 6 hours, which is consistent with minimum losses determined in previous studies for the New England area. Table A-V presents rates of precipitation, losses, and rainfall excess in the chronological order used to compute the standard project flood.

TABLE A-V

STANDARD PROJECT STORM RAINFALL

Time in Hours	Rainfall in Inches	Losses in Inches	Rainfall Excess in Inches
0	0.00		
6	0.25	0.25	--
12	0.40	0.40	--
18	0.45	0.42	0.03
24	0.55	0.42	0.13
30	7.40	0.42	6.98
36	1.05	0.42	0.63
42	0.60	0.42	0.18
48	0.50	0.42	0.08
54	0.35	0.35	--
60	0.20	0.20	--
66	0.15	0.15	--
72	0.10	0.10	--

A5.3 Unit hydrographs.- After a review of stream gaging and precipitation records, the floods of July 1938, September 1954, and August 1955 were selected for unit hydrograph analyses. These floods were analyzed to determine the contribution of various tributaries to the flood hydrographs at the Woonsocket gage. Because a unit duration of 6 hours was considered desirable for, and applicable to, a drainage area of 416 square miles, all hydrographs were converted to 6-hour unit hydrographs following the method prescribed in Engineering Manual, Civil Works, Part CXIV, Chapter 5, March 1948. The adopted unit hydrograph based on the analyses of the three floods is shown on Plate No. A-3.

A5.4 Standard project flood.- The standard project flood for the Blackstone River at the Woonsocket gage was derived by applying the SPS rainfall excess to the adopted unit hydrograph. Standard project floods were developed for both the Mill and Peters Rivers by the same method. The computed SPF hydrographs are shown on Plate No. A-3.

A5.5 Design discharge.- West Hill Dam and Reservoir, included in the authorized plan for flood control in the Blackstone River Basin, would effect reductions of Blackstone River flood flows in Woonsocket. The dam site is located on the West River, a tributary which enters the Blackstone River approximately 10 miles upstream from the center of Woonsocket. The effect of this reservoir on Blackstone River flood flows in Woonsocket was taken into account, because the dam is presently in the design phase. As a result, the standard project flood reduced by West Hill Reservoir was adopted as the design flood for local protection works in the Social and Hamlet Districts of Woonsocket. The Bernon Unit, a channel improvement, would afford a substantial degree of protection against the design flood in the vicinity of Bernon Dam and would effect a stage reduction for all ranges of flow. In the event that Harris Pond dam is reconstructed on the Mill River immediately upstream from the project area, it was assumed that adequate design of the new dam would preclude a recurrence of the August 1955 failure. The adopted design discharges are as follows:

River	Discharge (c.f.s.)
Blackstone above confluence of Mill & Peters Rivers	27,800
Blackstone below confluence of Mill & Peters Rivers	31,900
Mill River	6,700
Peters River	2,600

A6. ELEVATIONS OF DIKES AND FLOODWALLS

The plan of improvement for Lower Woonsocket includes the construction of dikes and floodwalls to protect properties adjacent to the Blackstone, Mill, and Peters Rivers. The elevation of the top of dike or floodwall at each location is based upon the elevation of the design discharge plus a minimum freeboard allowance of 3 feet. The grade of the dikes and walls in relation to the elevation of the design discharge is shown on Plate No. A-4.

A7. HYDRAULICS OF THE CONDUITS

A7.1 General.- The relative timing of the peak flows on the Mill and Peters Rivers with the flow on the Blackstone River was taken into account in the design of the pressure conduits for these tributaries. Based on analysis of floods of record, as reflected in the development of the standard project flood (See Plate No. A-3), the Mill and Peters Rivers peak approximately 13 hours earlier than the Blackstone River. Therefore, two conditions were investigated in the hydraulic study of the pressure conduits. The first condition assumes maximum discharge on each tributary with tailwater elevations corresponding to concurrent flow in the main river at the time of the tributary peak. The second condition assumes maximum discharge and stage on the Blackstone River with concurrent discharges on each tributary. Peak tributary discharge was found to control conduit design for both the Mill and Peters Rivers.

A7.2 Mill River conduit.- The plan for Mill River improvements includes dikes and channel excavation immediately upstream from the conduits. In view of this, the effect of conduit size on water surface elevation at the conduit entrance was considered. A double-barrel, rectangular conduit, each barrel 12' x 17', was selected. It would provide a total waterway opening of 408 square feet to carry runoff from the Mill River drainage area of 34.7 square miles. The conduit would have a length of 1,050 feet and a slope of 0.0034. For the design flood of 6,700 c.f.s., a velocity of 16.7 feet per second through the conduit was computed using an "n" value of 0.014. The total computed head loss through the conduit is 9.5 feet, consisting of 5.2 feet of friction and entrance losses and 4.3 feet of velocity head loss. The computed conduit losses were added to the concurrent Blackstone River tailwater elevation to determine the water surface elevation of the design discharge at the conduit headwall.

A7.3 Peters River conduit.- In selecting the size of the Peters River conduit, the effect on water surface elevation at the conduit entrance was considered, since the plan of improvement for the Peters River includes an upstream dike and floodwall. A single barrel 10' x 16' conduit, providing 160 square feet of waterway opening, was selected. It would carry runoff from the Peters River drainage area of 12.7 square miles. The conduit would have a length of 1,200 feet and a slope of 0.013. For the design discharge of 2,600 c.f.s. through the conduit, a velocity of 16.3 feet per second was computed using an "n" value of 0.014. The total computed head loss through the conduit is 11.6 feet, consisting of 7.5 feet of friction and entrance losses and 4.1 feet of velocity head loss. The computed conduit losses were added to the concurrent Blackstone River tailwater elevation to determine the water surface elevation of the design discharge at the conduit headwall.

A8. INTERIOR DRAINAGE

A8.1 General.- The discharge capacities of the pumping stations were based on the Rational Formula Q = CIA, where

Q = runoff in cubic feet per second

C = coefficient representing the ratio of rates of rainfall and runoff

I = maximum average rainfall intensity in inches per hour

A = drainage area in acres

The most severe conditions affecting the design capacity of the pumps would result from intense rainfall occurring during periods of high river stages. Based on studies of the pumping station for the authorized Woonsocket Local Protection Project, a rainfall intensity of 1.5 inches per hour coincident with a high stage of the Blackstone River was adopted.

A8.2 Social District Unit.- The drainage area that would contribute to the runoff within the dikes and floodwalls amounts to approximately 180 acres. The topography is relatively flat and the area contains numerous flat-roofed commercial and industrial properties and considerable paved and impervious surface area. Within the area to be protected, there is an existing storm sewer system to collect and discharge runoff. Using a "C" value of 0.5 for the detention storage of the area and the coincident rainfall intensity of 1.5 inches per hour, the computed discharge capacity of the pumping station amounts to 135 cubic feet per second, or 61,000 gallons per minute.

A8.3 Hamlet District Unit.- An area of approximately 150 acres, occupied mainly by industrial and residential properties, would contribute to the runoff within the dikes and floodwalls. The topography is relatively flat in the area immediately adjacent to the river and rises quite steeply away from the river. Within the area to be protected, there is an existing storm sewer system to collect and discharge runoff. A short section of trunk sewer would be relocated to discharge downstream from the dikes. Based on a "C" value of 0.5 for the detention storage of the area and a coincident rainfall intensity of 1.5 inches per hour, a pumping station capacity of 113 cubic feet per second, or 51,000 gallons per minute, was adopted.

A9. HYDRAULICS OF THE CHANNELS

A9.1 General.- The recommended plan of improvements includes the removal of Bernon Dam and of Hamlet Dam on the Blackstone River and excavation of the channel for a short distance in the vicinity of each dam. The Mill River would also be improved by widening, deepening, and realigning the channel from the headwall of the pressure conduit upstream to Privilege Street. Water surface profiles were determined by the Manning formula with allowances made for losses resulting from curvature, expansions and contractions of the channel, and bridge losses.

A9.2 Blackstone River channel.- Improvement of the Blackstone River channel would consist of removing two small dams, Bernon Dam and Hamlet Dam, and excavating a portion of the river channel in the vicinity of each dam to improve the hydraulic characteristics of the channel. The locations of Bernon Dam at Station 2+00 and Hamlet Dam at Station 31+50 are shown on the profiles on Plate No. A-4 at the end of this appendix. An "n" value of 0.035, increased to 0.040 for certain reaches of river to allow for curvature losses, was selected in computing the design flood profile. The removal of Bernon Dam and contiguous channel excavation would reduce the stage of the design flood by about 4-1/2 feet upstream from the dam. The improvements in the vicinity of Hamlet Dam would reduce the design flood stage by about 1 foot in the reach of river upstream from the dam. Similar reductions would be effected in a recurrence of the August 1955 flood. Water surface profiles for the design flood with and without recommended improvements and for the August 1955 flood are shown on Plate No. A-4. The profile of the existing and improved river bottom are also shown.

A9.3 Mill River channel.- Improvement of the Mill River channel would provide for realigning and excavating the present channel between Privilege Street and the headwall of the twin pressure conduit near Social Pond. The improved trapezoidal channel would have a 70-foot bottom width, 1 vertical on 2 horizontal side slopes, and a bottom slope of 0.0089. The water-surface profile for the design discharge was determined by computing backwater from the conduit headwall to the upper limit of the improvement. An "n" value of 0.033 was used in computing the design flood profile.

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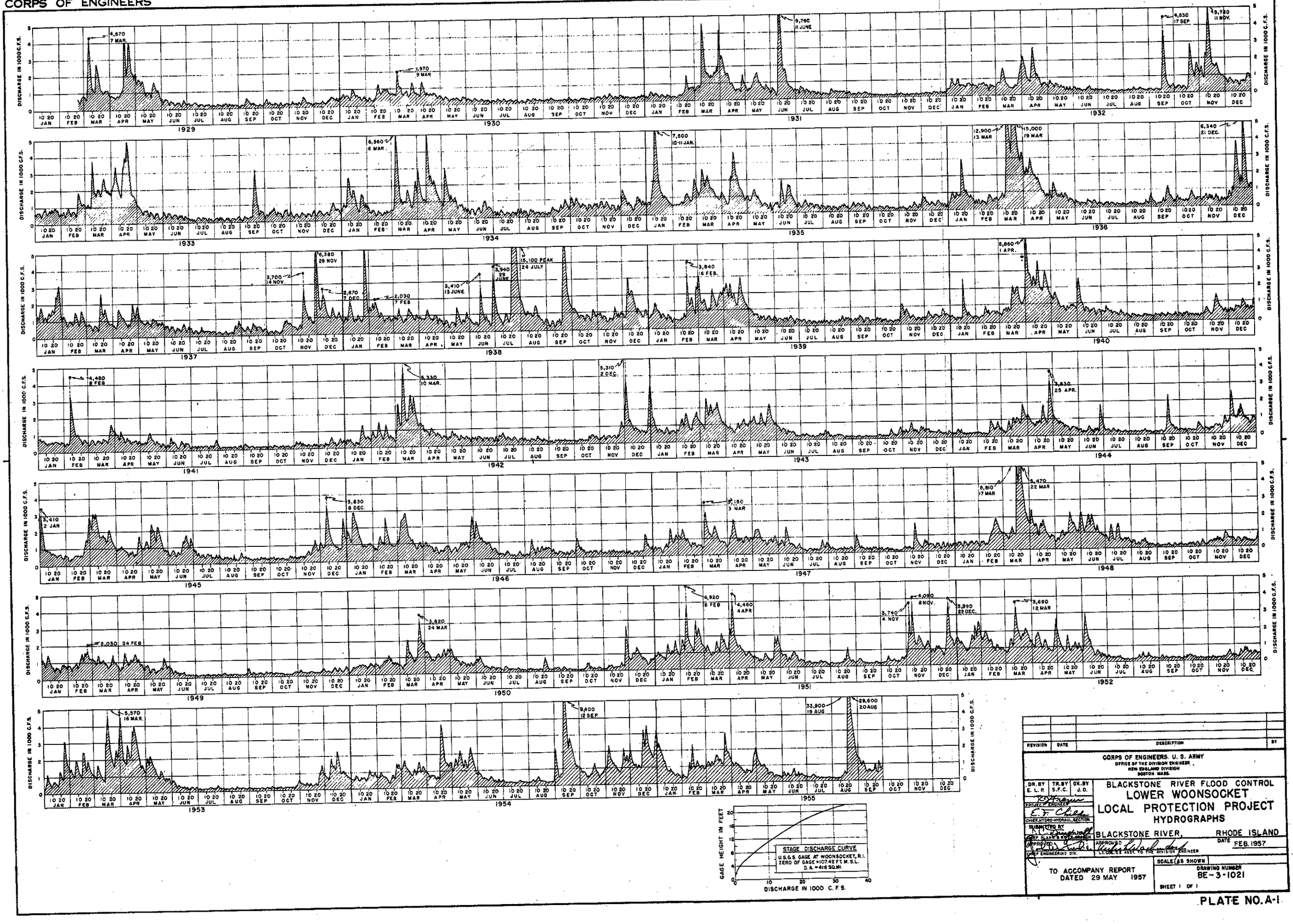

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NEW ENGLAND DIVISION
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PROJECT ENGINEER
CHIEF, HYDRO-HYDRAUL. SECTION
SUBMITTED BY
CHIEF PLANS & SURVEYS BRANCH
APPROVED
CHIEF ENGINEERING DIV.

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
HYDROGRAPHS

BLACKSTONE RIVER, RHODE ISLAND

APPROVED
CHIEF, CE ASST. TO THE DIVISION ENGINEER

DATE FEB. 1957

SCALE AS SHOWN

TO ACCOMPANY REPORT
DATED 29 MAY 1957

DRAWING NUMBER
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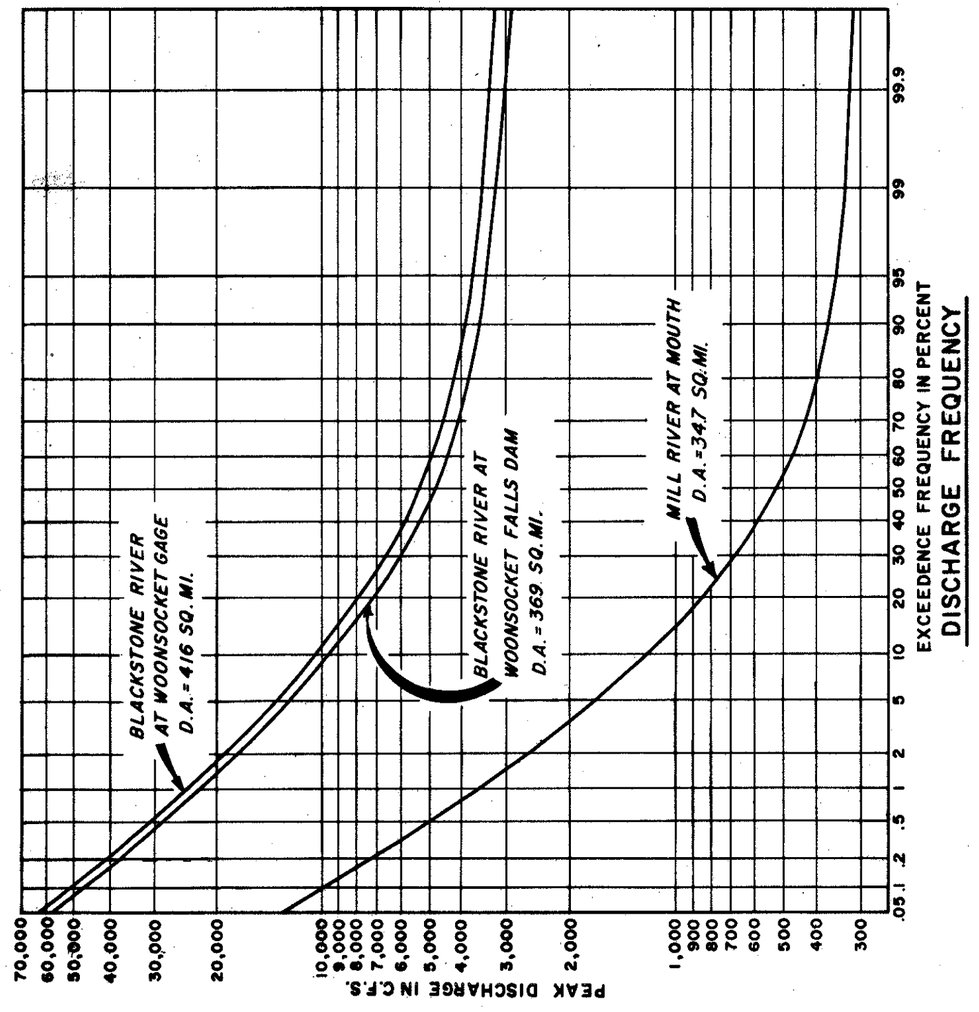
SHEET 1 OF 1

PLATE NO. A-1



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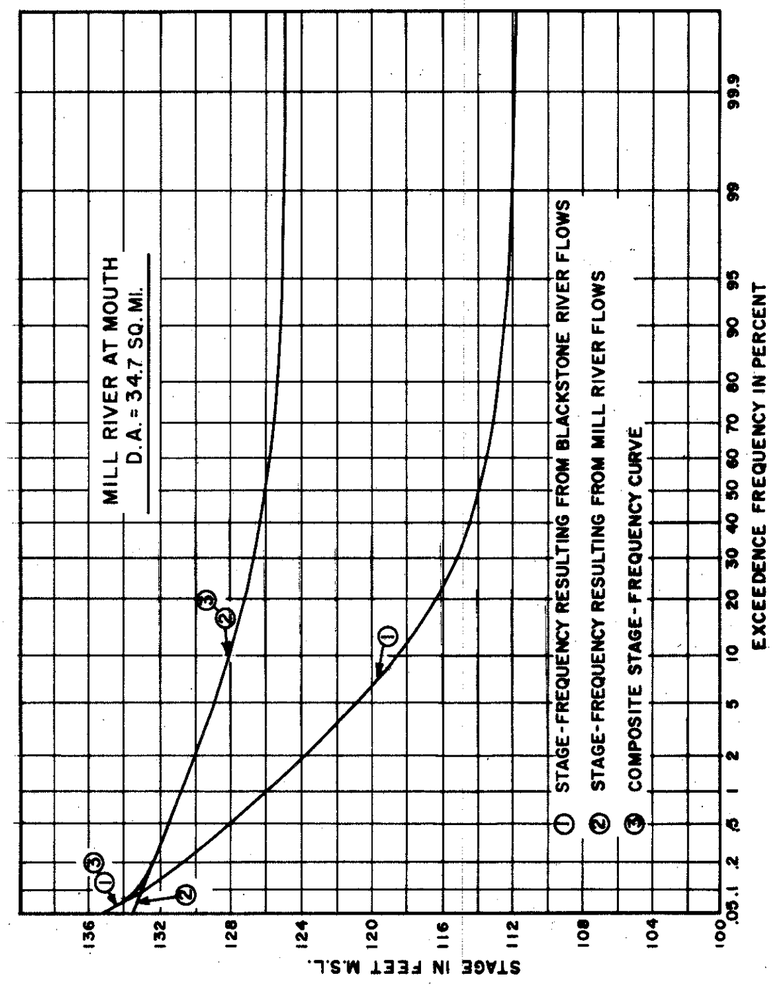


STAGE FREQUENCY

BLACKSTONE RIVER FLOOD CONTROL

LOWER WOONSOCKET

LOCAL PROTECTION PROJECT

NATURAL FREQUENCY CURVES

NEW ENGLAND DIVISION - BOSTON, MASS.

FEBRUARY 1957

PLATE NO. A-2

HYETOGRAPH

RAINFALL & RAINFALL EXCESS IN INCHES PER 6 HOURS

0
2
4
6

LOSS

EXCESS

STANDARD PROJECT FLOOD

34,500 C.F.S. BLACKSTONE RIVER AT WOONSOCKET GAGE

AUGUST 1955 FLOOD PEAKS AT WOONSOCKET GAGE:

32,900 c.f.s. with dam failure

29,600 c.f.s. without dam failure

30,000 C.F.S. BLACKSTONE RIVER AT WOONSOCKET FALLS DAM

DISCHARGE IN 1,000 C.F.S.

0
5
10
15
20
25
30

6700 C.F.S. MILL RIVER AT MOUTH

2600 C.F.S. PETERS RIVER AT MOUTH

0 24 48 72 96 120 144 168

TIME IN HOURS FROM BEGINNING OF RAINFALL EXCESS

4270 C.F.S. BLACKSTONE RIVER AT WOONSOCKET GAGE

3720 C.F.S. BLACKSTONE RIVER AT WOONSOCKET FALLS DAM

6-HOUR UNIT HYDROGRAPH

DISCHARGE IN 1,000 C.F.S.

0
1
2
3
4

870 C.F.S. MILL RIVER

330 C.F.S. PETERS RIVER

0 12 24 36 48 60 72 84 96 108 120 132 144 156 168 180

TIME IN HOURS FROM BEGINNING OF RAINFALL EXCESS

DESIGN DISCHARGE

(S.P.F. MODIFIED BY AUTHORIZED WEST HILL RESERVOIR)

⊙ 31,900 c.f.s. AT WOONSOCKET GAGE

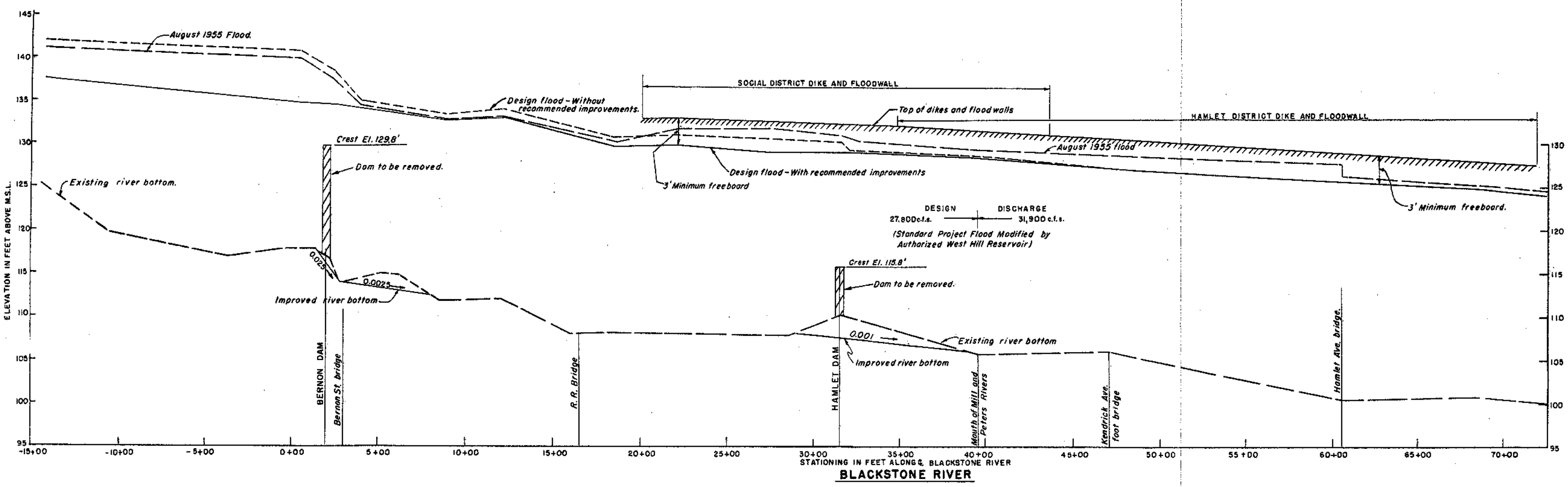
⊡ 27,800 c.f.s. AT WOONSOCKET FALLS DAM

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT

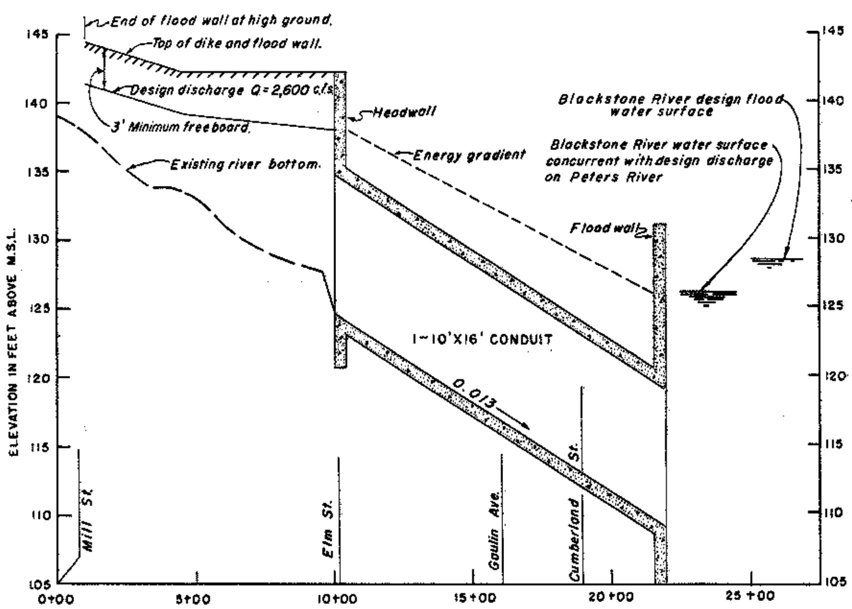
STANDARD PROJECT FLOOD

NEW ENGLAND DIVISION BOSTON MASS.
FEBRUARY 1957

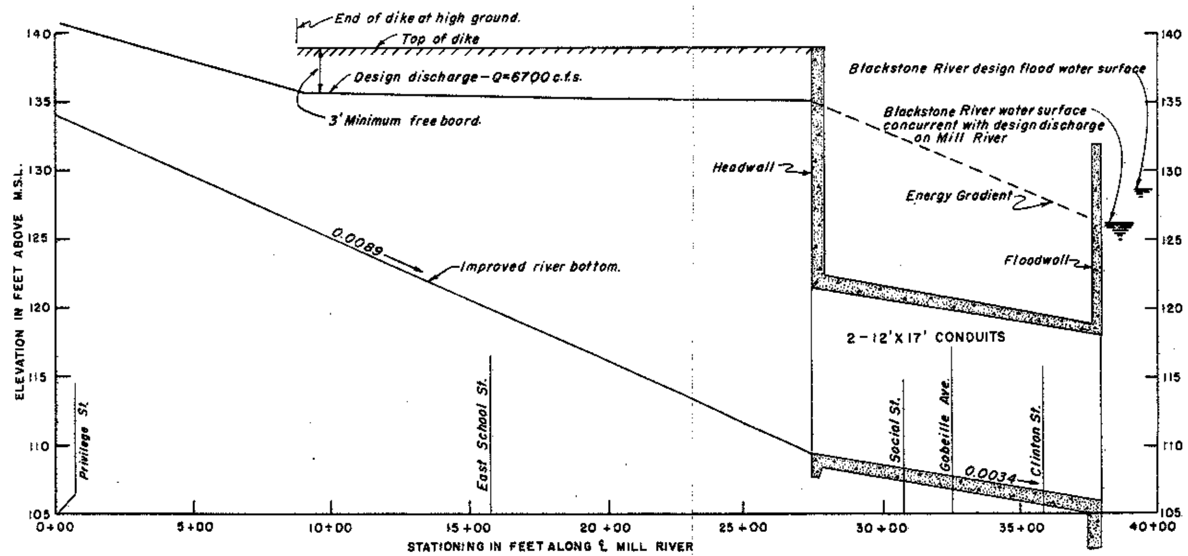
PLATE NO. A-3



BLACKSTONE RIVER



PETERS RIVER



MILL RIVER

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS U. S. ARMY

S.F.C. P.W.G. G.F.B.

HYD. & HYD. SECTION

BLACKSTONE RIVER FLOOD CONTROL

LOWER WOONSOCKET

LOCAL PROTECTION PROJECT

WATER SURFACE PROFILES

BLACKSTONE, MILL & PETERS RIVERS, RHODE ISLAND

DATE MAY, 1957

SCALE: AS SHOWN

TO ACCOMPANY REPORT DATED 29 MAY 1957

DRAWING NUMBER BE-3-1022

PLATE NO. A-4

APPENDIX B

GEOLOGY

APPENDIX B

GEOLOGY

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APPENDIX B

GEOLOGY

B1. TOPOGRAPHY

The Woonsocket area lies within the Seaboard Lowland Section of the New England Physiographic Province in a region of moderate but sharp relief and broad valleys. The topography of the region is the result of long continued pre-glacial erosion modified by glacial and post-glacial erosion and deposition. It is to a large degree bedrock controlled. The Blackstone River, flowing generally southeasterly through the region, together with its tributaries, constitutes the regional drainage.

B2. EXPLORATIONS

Explorations in the project area consisted of geologic reconnaissance supported by data obtained from dam and bridge drawings and from well records included in a report entitled The Geology and Groundwater Resources of Woonsocket, Rhode Island, published in 1950. This report was prepared jointly by the Rhode Island Port and Indestrial Development Commission and the U. S. Geological Survey. The area reconnoitered extends from South Main Street Bridge downstream to a point well below the outlet of Hamlet Trench. It also includes the tributary Mill and Peters Rivers within the survey area. The purpose of the reconnaissance was to study the general geology of the area, map bedrock exposures, and determine as far as possible, with respect to excavation and bearing properties, the character of materials present.

B3. GEOLOGY

B3.1 General.- The Blackstone River flows southeasterly into Woonsocket and, just downstream from South Main Street, swings sharply to the northeast for about a mile. It enters the project area on this northeasterly course, turns again below Hamlet Dam and flows to the southeast through the lower end of the project area. Topography and surficial geology indicate that the Blackstone River is flowing in its pre-glacial valley in this area. The river is superimposed on glacial drift which deeply buries its pre-glacial channel except where, in its post-glacial meandering, it has encountered old valley walls at Woonsocket Falls and in the right bank at Bernon Dam and Hamlet Dam. The Mill and Peters Rivers in the project area are also flowing on glacial drift.

B3.2 Overburden.- Overburden materials in the region consist mainly of two types of glacial drift: till and outwash. There are also lesser amounts of recent alluvium. In the project area, however, outwash materials alone constitute the bulk of the overburden.

The outwash materials in the project area are predominantly valley fill, consisting of a variably sorted combination of gravel, sand, and silt. Reconnaissance and well data on the right bank in the Hamlet District indicate 50 to 80 feet of sand and gravel in the flood plain extending from the Hamlet Trench outlet upstream to a point opposite the mouth of the Mill River. The thickest known accumulation of these materials in the project area occurs along the Peters River just below Mill Street, where well data indicates over 100 feet of sand and gravel. In the Social District-Mill River area, these deposits occur generally throughout. However, well data indicates that the accumulation is thin for the most part, in the order of 10 to 15 feet. One exception to this general thinness is in an area along the Mill River just south of East School Street, where a well was found to have penetrated some 50 feet of sand and gravel. From the Social District and Mill River area upstream to the vicinity of Bernon Street, there appears to be a general thickening of these materials to depths of 25 to 30 feet.

Deposits of alluvium are present to depths of 1 to 15 feet in the flood plains along the Blackstone River. They consist mainly of silty fine sands and silt with a variable mixture of debris in the upper portions. These deposits generally overlay sands and gravels but occasionally rest on rock, as in the southwest part of the Social District south of Social Street.

B3.3 Bedrock.- Bedrock is exposed at, or just above, river level at three locations along the Blackstone River in the general area of the project. Well logs and dam and bridge construction drawings provided additional data for a local delineation of the bedrock surface in the area.

The most southerly bedrock exposure in the project area is at the east end of Hamlet Avenue Bridge, where rock is exposed at the river's edge at an elevation of about 115 feet. Bedrock is also exposed at an elevation of about 150 feet in the nose of the sand and gravel hill just east of the bridge. Apparently, the bedrock surface falls away sharply to the west beneath the river, since a well located in the flood plain directly across the river from the outcrops indicates bedrock surface at an elevation of 50 feet.

A small exposure of variably weathered, slaty schist occurs in the canal at the south end of Hamlet Dam. The outcrop is at river level in the right bank of the canal at elevation 120+ feet. Across the river, the closest recorded bedrock surface elevations, 111, 121, 131 feet, are in three wells located from 1,000 to 1,300 feet to the west and northwest of the outcrop. North of Hamlet Dam, along the Mill River, well data

indicates bedrock elevations of 70 feet just south of East School Street and 125 feet at the westerly end of Oak Hill between East School Street and Privilege Street. The difference in bedrock surface elevations between the outcrop at the south end of Hamlet Dam and the closest record across the river is only 10± feet. However, the relatively wide intervals between recorded bedrock elevations, in an area known to be underlain with a variable rock surface, precludes an accurate determination of the bedrock position beneath the river in the vicinity of Hamlet Dam.

The third bedrock exposure is at the southeast end of Bernon Dam, about 3,000 feet upstream from Hamlet Dam. This outcrop is at and just above pool level, at an elevation of about 130 to 140 feet. Construction drawings of Bernon Dam show that the southeasterly two-thirds of the dam is founded on bedrock.

B3.4 Summary.- Available data indicates that the bulk of construction excavation on this project would be in outwash sands and gravels and in alluvial sands and silts. The excavations would involve little or no bedrock, except for portions of the channel excavations in the vicinity of Hamlet Dam and Bernon Dam. Other than the outcrop in the south bank, bedrock data in the vicinity of Hamlet Dam is speculative. From this data, it can be assumed that bedrock would be encountered to some extent in a portion of the channel excavation in the south bank near the dam, and perhaps in the south section of the riverbed. Available data also indicates that rock would be encountered to some extent in the south portion of the channel excavation in the vicinity of Bernon Dam.

There is no known glacial till in the project area. In other respects, the overburden materials are similar to those in the authorized project area upstream from South Main Street. It is assumed, therefore, that the materials would have similar excavation and bearing properties and, on this basis, no unusual excavation or foundation problems are anticipated. The bedrock, slaty schist with phyllitic phases, is also similar to that encountered in the authorized project area at Woonsocket Falls. It would have similar excavation properties, principally a tendency toward slabby fragmentation.

B4. CONSTRUCTION MATERIALS

B4.1 Pervious materials.- It appears that some of the construction earth excavations, generally the valley fill, would be suitable for use as random, pervious fill. This is based on test data of similar materials encountered in the authorized project area. In addition, vast quantities of moderately to well sorted, fairly clean sands and gravels are available within a 2 to 3 mile haul of the project area. These materials are present in numerous terrace features along the valleys in and around Woonsocket.

B4.2 Impervious materials.- Impervious materials in the region are represented in the glacial till which occurs on the tops and flanks of many of the hills. This till occurs generally in two phases: an upper phase, 10 to 15 feet thick, consisting of slightly impervious, sandy till; and a lower phase, considerably thicker, of more impervious, silty till. Field investigation revealed that, for one or more reasons, none of the possible sources near the project area could be utilized. Consideration then had to be given to potential sources within a 5 to 10 mile haul distance. The sandy till, with an average silt content of less than 5 percent, is the only till exposed at these locations. It represents, therefore, the only relatively impervious material known to be readily available for project use. It is probable that the more impervious, silty till underlies the sandy till at some of the locations. One such location, considered as a potential source of impervious material, is a drumloidal feature located approximately 1 mile south of Woonsocket Reservoir No. 3 and 5 miles south of the project area.

B4.3 Rock fill.- Required rock excavations would be in slaty schist with phyllitic phases. In excavating this rock, the phyllitic phases can be expected to shatter, while the slaty material will probably break out in 400 to 500 pound blocks. Considering the similarity of this rock to that in the authorized project area, it appears that little, if any, of this excavated rock would be sufficiently sound and blocky for use as rock fill material. The nearest commercial source of rock fill material is the Fanning and Doorley quarry in Berkeley, Rhode Island. The quarry is about a 7-mile haul distance from the project area.

B4.4 Gravel.- The project requirements for filter gravel and gravel bedding are limited. These materials can be most economically obtained from any of several commercial sources in the vicinity.

B4.5 Concrete aggregate.- Materials from five commercial sources were tested for use in the authorized project. Four of these are sources of sand and gravel and the fifth is a source of crushed stone. All were found acceptable for use as both fine and coarse aggregate in concrete. The haul distance from these sources to the project area is from 6 to 13 miles.

APPENDIX C

FLOOD LOSSES AND BENEFITS

APPENDIX C

FLOOD LOSSES AND BENEFITS

TABLES

PLATE

APPENDIX C

FLOOD LOSSES AND BENEFITS

C1. DAMAGE SURVEYS

Damage-survey parties were sent to the flood area immediately after the flood of August 1955. In view of the great increase in flood stages and losses over previous floods, the information gathered was referenced to 1955 flood stages. Correlation with data obtained after the 1936 and 1938 high waters was accomplished by an office review.

Essentially, the survey was a door-to-door inspection of the hundreds of industrial, commercial, residential, and other properties affected by the flood. Information obtained included the extent of the area flooded, descriptions of properties, the nature and amount of damages, depths of flooding, highwater references, and relationships to prior flood stages. Estimated evaluations of damage were generally furnished by property owners. Where these estimates appeared unrealistic, they were modified by the investigators. In those cases where owners were unable to furnish loss estimates, the investigators evaluated the flood losses. Sampling methods were employed where several residences of similar characteristics and like depth of flooding were encountered. Valuable information was also obtained from local and state officials and from utility companies which experienced damage at several points in this and other river basins. Central sources of information were used extensively to save time and to keep survey costs at a minimum.

Sufficient data was obtained to derive losses for (1) the 1955 stage; (2) a stage 3 feet in excess of 1955; (3) intermediate stages denoting sharp changes in stage-damage relationships; and (4) the stage where damage begins (zero damage) referenced to the 1955 flood level. Additional data was obtained for evaluation of enchancement or higher utilization of lands and commercial and industrial space.

C2. LOSS CLASSIFICATION

Flood-loss information was recorded by type of loss and by location. Loss types used were industrial, urban (commercial, residential, public), rural, highway, railroad, and utility. The type of loss was recorded by location within Lower Woonsocket and by reaches of the Blackstone, Mill, and Peters Rivers to provide a basis for later use in annual loss and benefit analysis.

Losses evaluated in the survey were the result of tangible primary damages. Primary losses comprise (1) physical losses such as damage to structures, machinery, stock, and the cost of clean-up and repairs; and (2) non-physical losses such as unrecovered loss of business, wages, or production; increased cost of operation; cost of temporary facilities; and increased cost of shipment of goods to persons and properties in the inundated areas.

The primary loss resulting from physical damages and a large part of the related non-physical loss are determined by direct inspection of property and evaluation of losses by the property owner and field investigators from this office. In some instances, the non-physical portion of the primary loss is difficult to estimate on the basis of information available at a given property. Where this condition exists, the relationship between physical and non-physical losses is based on the relationship found for similar properties in the area.

Monetary evaluations were not made of secondary damages or intangible losses. Secondary damages, incurred outside the immediate flood area under study, include such items as increased cost of travel and shipment of goods, the loss of utilities and transportation facilities, and business losses. Intangible losses include items such as loss of life, hazards to health, and detrimental effects on national security.

C3. RECURRING LOSSES

A recurrence of the August 1955 flood, without flood protection, would cause a total estimated loss of $10,200,000 in Lower Woonsocket, between South Main Street and the downstream city line. West Hill Reservoir would reduce these recurring losses to $7,150,000. Of this remaining loss, $6,140,000 would be prevented by the Lower Woonsocket Local Protection Project, with $4,900,000 attributable to the Social District Unit, $1,100,000 to the Hamlet District Unit, and $140,000 to the Bernon Unit. Residual losses of $1,010,000 would occur principally along the Blackstone River between Bernon Street bridge and the New York, New Haven and Hartford Railroad bridge and along the left bank downstream from Hamlet Avenue bridge. Protection to eliminate these residual losses would require extensive local protection works which lack economic justification at this time.

C4. AVERAGE ANNUAL LOSSES

Recurring losses have been converted to annual losses preliminary to evaluation of annual benefits. Annual losses have been derived in accordance with the standard practice of the Corps of Engineers of utilizing stage-damage, stage-discharge, and discharge-frequency relationships. Representative curves used for annual loss computations are shown on Plate C-1.

Stage-damage data for individual properties was summarized by reaches that have relatively uniform hydraulic characteristics throughout. The stage-damage relationships were correlated with stage-discharge relationships to develop a discharge-damage curve. The discharge-frequency relationship was then used to compute the damage-frequency relationship. The damage-frequency curve was plotted with damage as the ordinate and with percent chance of occurrence (reciprocal of frequency) as abscissa. The area under the damage-frequency curve represents the annual loss.

Total annual losses in the Lower Woonsocket area amount to $264,000. The West Hill Reservoir would reduce these annual losses to $215,000.

C5. FLOOD PREVENTION BENEFITS

Annual flood-prevention benefits were derived for the reaches downstream from South Main Street by determining the difference between annual losses that would remain after operation of the authorized West Hill Reservoir and those which would remain after supplementation by construction of the Lower Woonsocket Local Protection Project. A summary of annual losses and flood-prevention benefits is presented below.

SUMMARY OF ANNUAL LOSSES AND
FLOOD PREVENTION BENEFITS

	Residual Annual Losses		Annual Benefits
	After West Hill	After West Hill & Local Protection	
Social District Unit	$164,000	$50,000	$114,000
Hamlet District Unit	33,000	16,000	17,000
Bernon Unit	18,000	9,000	9,000
Total Lower Woonsocket Local Protection Project	$215,000	$75,000	$140,000

C6. ENHANCEMENT AND HIGHER UTILIZATION BENEFITS

C6.1 General.- An analysis of flood losses and benefits in Lower Woonsocket revealed that substantial development of lands currently idle and higher utilization of vacant industrial and commercial space can be expected to follow the construction of the flood protection project. The value of enhancement would be an additional benefit to the project. There is a demand for land and manufacturing space in existing buildings at locations in the established industrial and commercial zones of the community. Nearly 700,000 square feet of space in industrial plants outside the flood area was rented in 1956. The experience of four major floods in the last 30 years, climaxed by the disastrous flood of August 1955, precludes the rental of similar space in the flood area.

An extensive investigation of past, present, and potential future use of idle lands and vacant industrial and commercial space was made to obtain data for the economic analysis. In the course of this investigation, valuable data was obtained from responsible sources including city officials, bankers, real estate brokers, industrial managers, and representatives of the Chamber of Commerce, the Industrial Development Foundation of Greater Woonsocket, and the Retail Trade Board. The results of this study revealed (1) a definite need for development of idle lands and buildings; (2) a demand for space outside the flood area when, at the same time, similar or better space within the flood area remains unused; and (3) a specific potential for use of space in the flood area after construction of flood-protection measures.

The economic situation in Woonsocket is similar in many respects to other communities in Northeastern United States which were initially developed as a result of the textile industry. These communities, affected by a general decline within the textile industry, resurged in recent years with development in other fields. Manchester and Nashua in New Hampshire, and Lawrence and Lowell in Massachusetts are notable examples. Situated on natural watercourses, the textile industry located and developed in these communities by utilizing the available water for power and processing. In recent years Woonsocket, like other Northeast communities, was affected by this textile decline and was faced with the problem of alternate use of both labor supply and vacant mills. The city met with some success in attracting other industries to the area, notably manufacturers of machine tools, rubber goods, plastics, and electrical products. Several of these industries occupied new buildings constructed for their purposes, and others moved into idle textile plants. The Industrial Development Foundation of Greater Woonsocket constructed a new industrial park and was successful in encouraging the rental of factory space outside the flood area.

C6.2 Development of idle land. - An important segment of the industrial and commercial center of Lower Woonsocket is located within the protection area of the Social District Unit on the left bank of the Blackstone River. Established railroad and highway transportation, availability of existing facilities, present use of adjoining properties, and the buying habits of the public make the area attractive for further development upon construction of protective works. There are five properties that have good potential for development upon removal of the flood threat. Table C-I presents the property location, land area, type of potential development, estimated amount of initial investment, initial annual return, and estimated annual return over the economic life of the flood control project. The type of development anticipated for each of these properties represents the most conservative choice in terms of estimated monetary benefits.

The initial investment for development was based on conservative prices for light industrial and commercial space in the area. Space in one-story plants for light industry was estimated at $7.00 per square foot. The initial return on the investment, estimated at 7 percent of the investment, allows for 5 percent return to the investor and 2 percent tax return. The annual return was reduced to zero at the end of the economic life of the project, to offset the increased maintenance and investment required to maintain the initial rate of return throughout the life of the project.

C6.3 Utilization of idle industrial space. - There are four existing plants with space available for rent within the areas to be protected. Two of these plants are on the right bank. The total area available is 396,000 square feet. The rental of nearly 700,000 square feet of similar space in plants outside the flood area during 1956 indicates a definite market for former textile space, particularly in view of the relatively low rental charge. The average rental for this space in Woonsocket and in surrounding communities is $0.25 per square foot, of which $0.08 per square foot is the cost of services such as heat, water, elevator service, and maintenance, leaving a net rental income of $0.17 per square foot as the initial net return from rental of this space. Without additional investment or inordinately expensive maintenance, this return would be reduced to zero at the end of the economic life of the protective works. Table C-II presents the name, location, area, initial return, and average annual return for utilization of vacant industrial space upon construction of protective works.

TABLE C-I

ENHANCEMENT OF IDLE LAND
SOCIAL DISTRICT UNIT

Location	Land Area (sq. ft.)	Type of Development Anticipated	Estimated Investment	Initial Annual Return	Average Annual Return
Clinton St.	427,800	Light Industrial Bldg.	$1,000,000	$ 70,000	$35,000
Social St.	44,000	Stores	130,000	9,000	4,500
East School St.	60,000	Light Industry	140,000	9,800	4,900
Social, Clinton & Cumberland Sts.	10,000	Store and Office	130,000	9,000	4,500
Gobeille Ave.	27,000	Woodworking Shop	40,000	2,800	1,400
			$1,440,000	$100,600	$50,300

TABLE C-II

UTILIZATION OF IDLE INDUSTRIAL SPACE

Area	Name	Location	Space (sq.ft.)	Initial Return	Average Annual Return
Social District	Montrose Mill	East School St.	81,000	$13,800	$ 6,900
Social District	American Paper Tube	Hazel St.	48,000	8,200	4,100
Hamlet District	Verdun	Hamlet Ave. & Villanova St.	113,000	19,200	9,600
Hamlet District	Lafayette	Hamlet Ave.	154,000	26,200	13,100
			396,000	$67,400	$33,700

C6.4 Utilization of idle commercial space.- Some 189 commercial establishments located within the protection area of the Social District Unit were affected by the 1955 flood. Eleven of these establishments vacated after the flood and never reoccupied their previous quarters. The history of active retail merchandising in the area indicates that flood protection would result in reoccupancy of the idle stores. The stores have been rehabilitated and a few of them improved; but owing to the flood history, new enterprises decline to occupy the space, even though competition for commercial space is evident in the Social District.

Idle space comprises 27,700 square feet with 400 feet of frontage. Based on the rental value of comparable space in the area, $100 per month for 20 feet of frontage, the gross rental to be realized upon construction of flood protection amounts to $24,000 per year. The provision of heat, light, and water already borne by the property owner amounts to 12 percent, resulting in a net increase of $21,300 for the first year. Without additional expenditure for maintenance and repairs, this return would decline to zero at the end of the economic life of the protective works. The average annual increased return is estimated at $10,700 per year.

C6.5 Summary of utilization benefits.- The annual benefits to be realized from development of idle lands and utilization of idle industrial and commercial space are summarized below.

SUMMARY OF UTILIZATION BENEFITS

	Social District Unit	Hamlet District Unit	Total
Idle Land	$50,300	$ -	$50,300
Idle Industrial Space	11,000	23,000	34,000
Idle Commercial Space	10,700	-	10,700
Total	$72,000	$ 23,000	$95,000

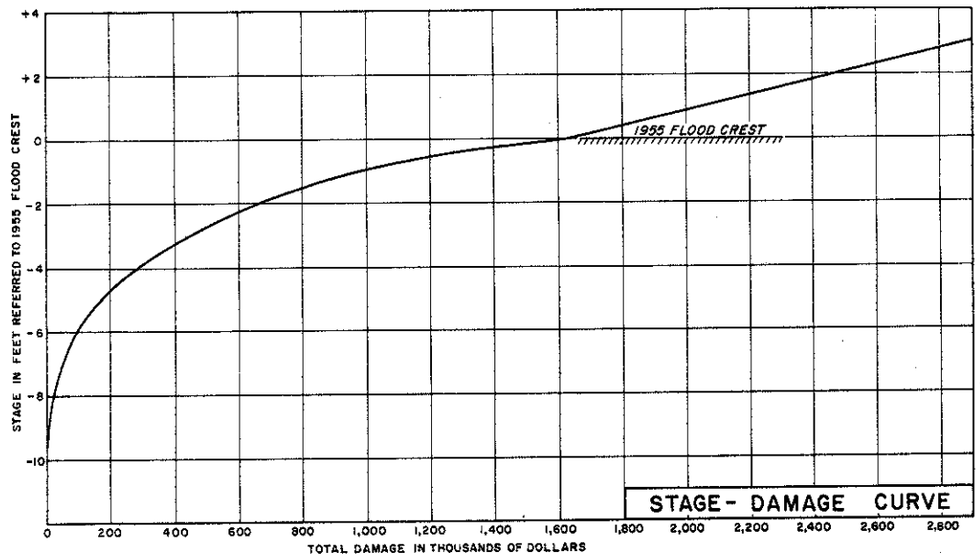
C7. SUMMARY OF BENEFITS

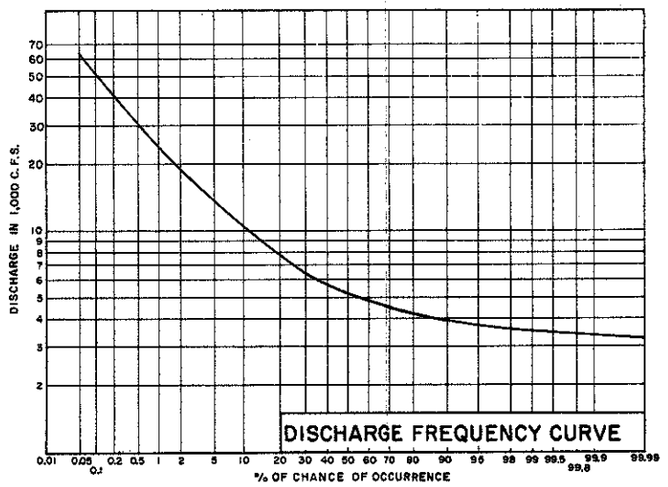
Total annual benefits for the Lower Woonsocket Local Protection Project, computed as incremental to those assigned to West Hill Dam and Reservoir, are presented in the following table.

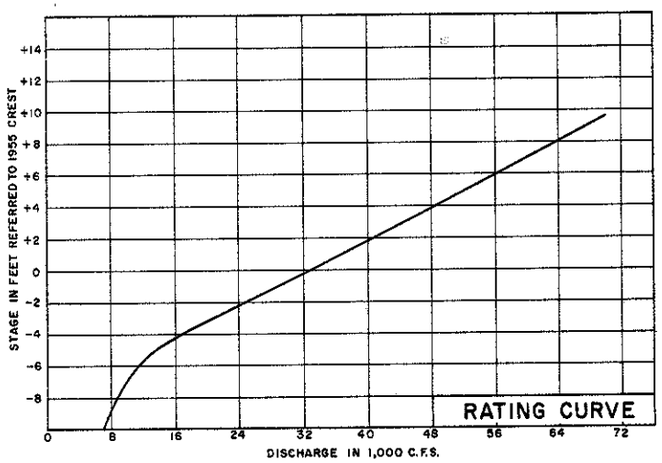
TABLE C-III

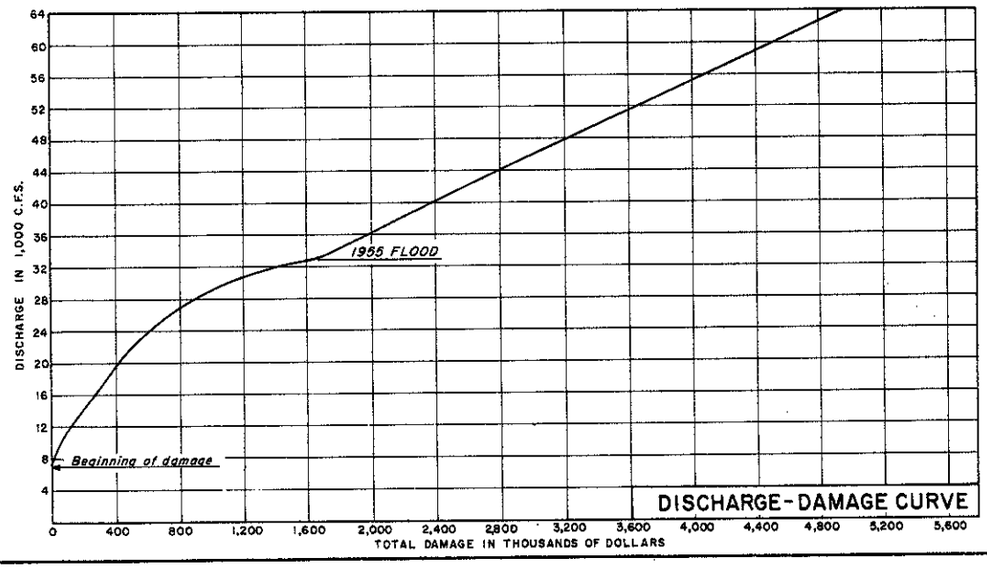
SUMMARY OF AVERAGE ANNUAL BENEFITS
LOWER WOONSOCKET LOCAL PROTECTION PROJECT

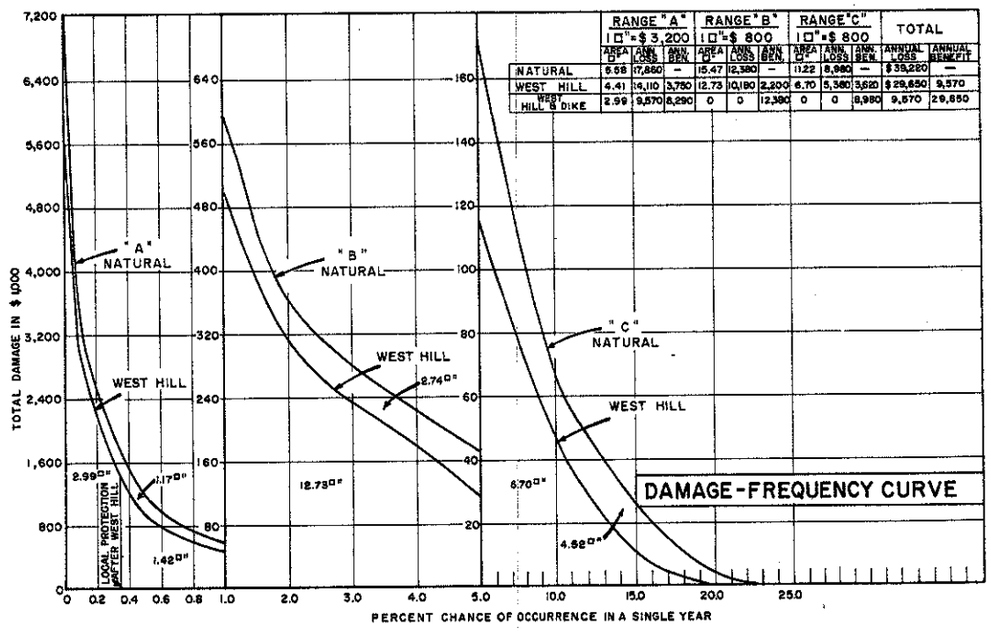
	Flood Prevention Benefits	Enhancement or Higher Utilization Benefits	Total Benefits
Social District Unit	$114,000	$72,000	$186,000
Hamlet District Unit	17,000	23,000	40,000
Bernon Unit	9,000	-	9,000
Total Lower Woonsocket Local Protection Project	$140,000	$95,000	$235,000











	RANGE "A" 1□"=$ 3,200			RANGE "B" 1□"=$ 800			RANGE "C" 1□"=$ 800			TOTAL	
	AREA □"	ANN. LOSS	ANN. BEN.	AREA □"	ANN. LOSS	ANN. BEN.	AREA □"	ANN. LOSS	ANN. BEN.	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL	5.56	17,850	—	15.47	12,380	—	11.22	8,980	—	$ 39,220	—
WEST HILL	4.41	14,110	3,750	12.73	10,180	2,200	6.70	5,360	3,620	$ 29,650	9,570
WEST HILL & DIKE	2.99	9,570	8,290	0	0	12,380	0	0	8,980	9,570	29,850

BLACKSTONE RIVER FLOOD CONTROL

LOWER WOONSOCKET

LOCAL PROTECTION PROJECT

TYPICAL CURVES FOR ECONOMIC ANALYSIS

NEW ENGLAND DIVISION BOSTON, MASS.

FEBRUARY 1957

PLATE NO. C-1

APPENDIX D

PROJECT PLAN AND ESTIMATES OF COST

APPENDIX D

PROJECT PLAN AND ESTIMATES OF COST

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APPENDIX D

PROJECT PLAN AND ESTIMATES OF COST

D1. SCOPE OF PROJECT

The Lower Woonsocket Local Protection Project would consist of three independent flood protection units, referred to separately as the "Social District Unit", the "Hamlet District Unit", and the "Bernon Unit". The Social District Unit and the Hamlet District Unit are designed to protect against the standard project flood as modified by operation of the authorized West Hill Reservoir. The Bernon Unit, a channel improvement, would reduce the stage of all floods in the vicinity of Bernon Dam and, in a flood of August 1955 magnitude, would reduce stages by about 4-1/2 feet upstream from the dam.

The Social District Unit, which is the largest unit, would be an integrated system of floodwalls, dikes, conduits, channel excavation, and a pumping station on the left bank of the Blackstone River and along the lower sections of the tributary Mill and Peters Rivers. This unit would also include the removal of Hamlet Dam and channel excavation in the Blackstone River adjacent to the left bank dike and floodwall. The Hamlet District Unit would consist of a dike, floodwall, and pumping station on the right bank of the Blackstone River. The removal of Bernon Dam on the Blackstone River combined with channel excavation in the vicinity of the dam would constitute the Bernon Unit.

The project features are further described in the following sections and are shown on the plates bound at the end of this appendix. See Tables D-I through D-VIII for estimates of first costs and annual charges.

D2. DESCRIPTION OF SOCIAL DISTRICT UNIT

D2.1 General.- The Social District Unit of the Lower Woonsocket Local Protection Project would be located in the Social District of the City of Woonsocket, along the left bank of the Blackstone River and along two of its tributaries, the Mill and Peters Rivers. A dike and floodwall along the Blackstone River would protect the Social District from overflows of the Blackstone River. The removal of Hamlet Dam and channel excavation adjacent to the dike and floodwall would also be accomplished. Improvements along the Mill and Peters Rivers, including pressure conduits, would prevent these streams from overflowing behind the main river works and provide for tributary discharges through the Blackstone River floodwall. A pumping station with a capacity of 61,000 g.p.m. would handle interior drainage.

D2.2 Blackstone River features.- The dike and floodwall along the left bank of the Blackstone River would have an aggregate length of about 2,550 feet. The dike would start at high ground near the upper end of the Social District and extend downstream to connect to the floodwall. This floodwall would then extend downstream from the dike, cross the mouths of the Mill and Peters Rivers, and tie into high ground near the Kendrick Avenue footbridge. In addition, Hamlet Dam would be removed and the river channel would be excavated for a distance of about 1,300 feet adjacent to the dike and floodwall in order to improve the channel cross-sectional area.

Pertinent Data - Blackstone River Features (Social District Unit)

Dike

Type	Rolled earth
Length	1,600 feet
Average height above ground	10 feet
Freeboard above design flood	3 feet

Floodwall

Type	Reinforced concrete T-wall
Length	950 feet
Average height above ground	15 feet
Freeboard above design flood	3 feet

Channel Improvement

Length	1,300 feet
Bottom width	110 to 140 feet
Sideslopes	1 vertical on 2 horizontal

D2.3 Mill River features.- A channel improvement, pressure conduit, and two dikes would be constructed along the Mill River. The channel improvement would extend from Privilege Street downstream to the conduit which, in turn, would extend to the Blackstone River floodwall. In order to prevent Mill River flood discharges from bypassing the conduit, the new channel would be diked along both banks for part of its length.

In the event that Harris Pond dam is reconstructed on the Mill River upstream from the project area, it was assumed that the new dam would be adequately designed to prevent a recurrence of the August 1955 failure.

Pertinent Data - Mill River Features (Social District Unit)

Channel Improvement

Length	2,740 feet
Bottom width	70 feet
Sideslopes	1 vertical on 2 horizontal

Conduit

Type	Reinforced concrete
Length	1,050 feet
Size	2 - 12 by 17 feet

Dikes

Type	Rolled earth
Length	2,900 feet
Average height above ground	10 feet
Freeboard above design flood	3 feet

D2.4 Peters River features.- A pressure conduit would be constructed along the Peters River from Elm Street downstream to the Blackstone River floodwall. In order to prevent tributary flood discharges from bypassing the conduit, 900 feet of dike and floodwall would be required along the right bank of this stream from Elm Street upstream to Mill Street.

Pertinent Data - Peters River Features (Social District Unit)

Conduit

Type	Reinforced concrete
Length	1,200 feet
Size	10 by 16 feet

Dike

Type	Rolled earth
Length	550 feet
Average height above ground	4 feet
Freeboard above design flood	3 feet

Floodwall

Type	Reinforced concrete T-wall
Length	350 feet
Average height above ground	4 feet
Freeboard above design flood	3 feet

D2.5 Relocations.- Construction of the Social District Unit would require alteration of utilities at five points where the conduits would cross an existing street. Channel excavation in the Blackstone River would necessitate the underpinning of several electric transmission line towers. Modification of the storm drainage system would also be necessary to adapt the system to proposed pumping station and interior drainage requirements.

The City of Woonsocket plans to construct two bridges to replace existing temporary crossings on the Mill River in the project area, at East School Street and at Privilege Street. The design of the new structures will be coordinated with the requirements of the local protection works.

Representatives of the Blackstone Valley Gas and Electric Company, owner of Hamlet Dam, have informally indicated that they would offer no opposition to the removal of the dam since the company no longer makes use of it. However, three textile firms have rights to use water which is presently diverted by the dam into Hamlet Trench and pumped into the mills. Removal of the dam would require modification of existing water-pumping facilities so that water could be pumped directly from the river.

D2.6 Plan of construction.- Two construction seasons would be required for the initiation and completion of all construction. The pressure conduits would be constructed during the first season and all other work would be accomplished during the second season.

D3. DESCRIPTION OF HAMLET DISTRICT UNIT

D3.1 Protective works.- The Hamlet District Unit of the Lower Woonsocket Local Protection Project would consist of a dike and floodwall along the right bank of the Blackstone River in the City of Woonsocket. This unit would protect a group of textile plants from Blackstone River overflows in the Hamlet District. A pumping station with a capacity of 51,000 g.p.m. would discharge interior drainage.

Pertinent Data - Hamlet District Unit

Dike

Type	Rolled earth
Length	3,000 feet
Average height above ground	9 feet
Freeboard above design flood	3 feet

Floodwall

Type	Reinforced concrete T-wall
Length	150 feet
Average height above ground	6 feet
Freeboard above design flood	3 feet

D3.2 Relocations.- Construction of the Hamlet District Unit would require the relocation of a short section of existing unpaved access road. Modification of the storm drainage system would also be necessary in order to adapt the system to proposed pumping station and interior drainage requirements.

D3.3 Plan of construction.- One calendar year would be required for construction of the Hamlet District Unit.

D4. DESCRIPTION OF BERNON UNIT

D4.1 Protective works.- The Bernon Unit would provide for the removal of Bernon Dam on the Blackstone River combined with excavation of the river channel in the vicinity of the dam. This unit, a channel improvement, would reduce flood stages in the vicinity of Bernon Dam and benefit nearby industrial and commercial properties.

Pertinent Data-Bernon Unit

Channel Improvement

Length	600 feet
Bottom width	110 to 180 feet
Sideslopes	1 vertical on 2 horizontal

D4.2 Relocations.- Construction of the Bernon Unit would require the underpinning of the right abutment of Bernon Street bridge.

D4.3 Plan of construction.- One construction season would be required for construction of the Bernon Unit.

D5. COST ESTIMATES

D5.1 Basis of estimates.- The costs of the Lower Woonsocket Local Protection Project have been estimated on the basis of a design which would provide economical and safe structures for the given conditions. Quantities have been estimated on the basis of net outlines of the proposed design and foundation requirements. Earth borrow items include stripping borrow areas, spoil, loss from borrow to fill, and compactions in fill. Rock borrow estimates provide for swell from excavation to fill. Consideration was given to utilizing, wherever possible, materials from required excavations in lieu of borrow materials.

D5.2 Unit prices.- Unit prices are based on average bid prices for similar projects constructed, under construction, or under contract in New England. The adopted unit prices are adjusted to the 1956 price level and include minor items of work which do not appear in the cost estimates.

D5.3 Contingencies, engineering, and overhead.- Estimates of construction costs have been increased by 20 percent to cover contingencies. The costs for engineering and overhead are estimated lump sums based on knowledge of the site and experience on similar projects.

D5.4 Lands and damages.- Land requirements include allowances for borrow and spoil areas as well as sites for dikes, floodwalls, conduits, channel improvements, and appurtenant structures. However, no estimate has been made of the value of water rights at Bernon Dam, which is owned by the Blackstone Valley Gas and Electric Company. Representatives of the company have informally indicated that the generating facilities are old, that the installation furnishes less than one percent of the city's power requirements, and that they would offer no opposition to removal of the dam. The cost of the water rights, an item of local responsibility, is not expected to materially affect project economics and would have no bearing on Federal costs. The estimates of cost to local interest for lands, easements, and rights-of-way are based on current market values, field reconnaissance, and information secured from local officials.

D5.5 Local costs.- The cost of lands, easements, and rights-of-way would be a local responsibility in accordance with Section 3 of the Flood Control Act of 1936. The responsibility for the relocation or modification of highway facilities and utilities would also rest with

local interests under the above requirements. In addition, local interests would be required to hold and save the United States free from damages due to the construction works and maintain and operate the project after completion.

In addition to the responsibilities outlined in the previous paragraph, local interests would be required to make a cash contribution towards the cost of the project, because a portion of the project benefits are realized from enhancement or increased utilization of properties. Tables D-IV and D-V at the end of this Appendix set forth the development of the amount of contributed funds.

D5.6 Basis of annual charges.- Estimates of Federal annual charges comprise the interest on the investment plus an amount required to amortize the investment over a period of 50 years. The investment represents the first cost plus interest accrued during the estimated construction period. An interest rate of 2.5 percent was used in computing annual charges. Non-Federal interest and amortization charges were computed in the same manner.

Non-Federal annual charges include, in addition to interest and amortization charges, amounts for maintenance and operation and for tax loss on lands. The estimated annual cost for maintenance and operation of the project is based on knowledge of the site and on similar projects in New England. The estimated tax loss is based on the value of lands without improvements. An allowance, expressed on an annual basis, is also made for the interim replacement of equipment.

TABLE D-1

ESTIMATE OF FIRST COSTS

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
SOCIAL DISTRICT UNIT

	Estimated Quantity	Unit	Unit Cost	Estimated Amount	Total
LANDS, DAMAGES, AND RELOCATIONS					
Lands & Damages					
Land				$ 92,000	
Improvements				105,000	
Resettlement				3,000	
Contingencies				40,000	
Acquisition				35,000	
Total Lands & Damages					$275,000
Relocations					
Roads			L.S.	10,000	
Utilities			L.S.	188,000	
Contingencies				40,000	
Engineering & Overhead				47,000	
Total Relocations					285,000
TOTAL LANDS, DAMAGES, AND RELOCATIONS					$560,000
CONSTRUCTION					
Channels					
Remove Existing Structures	1	Job	L.S.	7,000	
Stream Control	1	Job	L.S.	10,000	
Common Excavation, Channel					
Class "A"	27,000	C.Y.	2.00	54,000	
Class "B"	155,000	C.Y.	0.90	140,000	
Rock Excavation, Channel	3,000	C.Y.	10.00	30,000	
Rock Excavation, Borrow	10,000	C.Y.	4.50	45,000	
Rock Fill	12,000	C.Y.	1.80	22,000	
Gravel Bedding	4,000	C.Y.	2.70	11,000	
Remove Hamlet Dam	1	Job	L.S.	27,000	
Remove Bridge Pier	1	Job	L.S.	2,000	
Miscellaneous Items			L.S.	35,000	
Contingencies				77,000	
Total Channels					$460,000

TABLE D-I (cont'd)

	Estimated Quantity	Unit	Unit Cost	Estimated Amount	Total
Dikes & Floodwalls					
Remove Existing Structures	1	Job	L.S.	$ 5,000	
Stream Control	1	Job	L.S.	20,000	
Common Excavation, General	35,000	C.Y.	0.90	32,000	
Conduit	37,000	C.Y.	2.00	74,000	
Borrow	37,000	C.Y.	1.50	56,000	
Rock Excavation, Borrow	4,000	C.Y.	4.50	18,000	
Embankment, Rolled	86,000	C.Y.	0.40	34,000	
Rock Fill	5,000	C.Y.	1.80	9,000	
Gravel Bedding	2,000	C.Y.	2.70	5,000	
Backfill	18,000	C.Y.	0.50	9,000	
Concrete, Floodwall	3,200	C.Y.	85.00	272,000	
Concrete, Conduit	9,500	C.Y.	75.00	713,000	
Interior Drainage	1	Job	L.S.	20,000	
Topsoil & Seed	15,000	S.Y.	0.85	13,000	
Miscellaneous Items			L.S.	128,000	
Contingencies				282,000	
Total Dikes & Floodwalls					$1,690,000
Pumping Station					
Structure	1	Job	L.S.	72,000	
Equipment	1	Job	L.S.	125,000	
Miscellaneous Items			L.S.	20,000	
Contingencies				43,000	
Total Pumping Station					260,000
Engineering & Design					240,000
Supervision & Administration					190,000
TOTAL CONSTRUCTION					$2,840,000
TOTAL LANDS, DAMAGES, AND RELOCATIONS					$ 560,000
TOTAL FIRST COSTS (Social District Unit)					$3,400,000

	Federal First Cost	Non-Federal First Cost	Total
Lands & Damages	$ -	$ 275,000	$ 275,000
Relocations	-	285,000	285,000
Construction	2,400,000	440,000*	2,840,000
Total	$2,400,000	$1,000,000	$3,400,000

*See Table D-IV for the determination of the amount of contributed funds.

TABLE D-II

ESTIMATE OF FIRST COSTS
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
HAMLET DISTRICT UNIT

	Estimated Quantity	Unit	Unit Cost	Estimated Amount	Total
LANDS, DAMAGES, AND RELOCATIONS					
Lands & Damages					
Lands				$29,000	
Improvements				21,000	
Resettlement				1,000	
Contingencies				10,000	
Acquisition				9,000	
Total Lands & Damages					$ 70,000
Relocations					
Roads			L.S.	13,000	
Utilities			L.S.	22,000	
Contingencies				7,000	
Engineering & Overhead				8,000	
Total Relocations					50,000
TOTAL LANDS, DAMAGES, AND RELOCATIONS					$120,000
CONSTRUCTION					
Dike & Floodwall					
Remove Existing Structures	1	Job	L.S.	5,000	
Stream Control	1	Job	L.S.	5,000	
Common Excavation, General	20,000	C.Y.	0.90	18,000	
Borrow "A"	21,000	C.Y.	1.50	32,000	
Borrow "B"	50,000	C.Y.	0.50	25,000	
Rock Excavation, Borrow	2,000	C.Y.	4.50	9,000	
Embankment, Rolled	71,000	C.Y.	0.40	28,000	
Rock Fill	3,000	C.Y.	1.80	6,000	
Gravel Bedding	2,000	C.Y.	2.70	5,000	
Concrete Floodwall	250	C.Y.	85.00	21,000	
Interior Drainage	1	Job	L.S.	28,000	
Topsoil & Seed	8,000	S.Y.	0.85	7,000	
Miscellaneous Items			L.S.	19,000	
Contingencies				42,000	
Total Dike & Floodwall					$250,000

TABLE D-II (cont'd)

	Estimated Quantity	Unit	Unit Cost	Estimated Amount	Total
Pumping Station					
Structure	1	Job	L.S.	$ 70,000	
Equipment	1	Job	L.S.	112,000	
Miscellaneous			L.S.	18,000	
Contingencies				40,000	
Total Pumping Station					$240,000
Engineering & Design					50,000
Supervision & Administration					40,000
TOTAL CONSTRUCTION					$580,000
TOTAL LANDS, DAMAGES, AND RELOCATIONS					$120,000
TOTAL FIRST COSTS (Hamlet District Unit)					$700,000

	Federal First Cost	Non-Federal First Cost	Total
Lands & Damages	$ -	$ 70,000	$ 70,000
Relocations	-	50,000	50,000
Construction	450,000	130,000*	580,000
Total	$450,000	$ 250,000	$ 700,000

*See Table D-V for the determination of the amount of contributed funds.

TABLE D-III

ESTIMATE OF FIRST COSTS*
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
BERNON UNIT

	Estimated Quantity	Unit	Unit Cost	Estimated Amount	Total
LANDS, DAMAGES, AND RELOCATIONS					
Lands & Damages					
Lands				$ 1,000	
Improvements				9,000	
Contingencies				2,000	
Acquisition				2,000	
Total Lands & Damages					$ 14,000
Relocations					
Road (Underpin Bridge)	1	Job	L.S.	15,000	
Contingencies				3,000	
Engineering & Overhead				3,000	
Total Relocations					21,000
TOTAL LANDS, DAMAGES, AND RELOCATIONS					$ 35,000
CONSTRUCTION					
Channel					
Remove Bernon Dam and Appurtenant Structures	1	Job	L.S.	33,000	
Common Excavation, Channel	15,000	C.Y.	2.00	30,000	
Rock Excavation, Channel	2,000	C.Y.	10.00	20,000	
Contingencies				17,000	
Total Channel					$100,000
Engineering & Design					12,000
Supervision & Administration					8,000
TOTAL CONSTRUCTION					$120,000
TOTAL LANDS, DAMAGES, AND RELOCATIONS					$ 35,000
TOTAL FIRST COSTS (Bernon Unit)					$155,000

	Federal First Cost	Non-Federal First Cost	Total
Lands & Damages	$ -	$ 14,000	$ 14,000
Relocations	-	21,000	21,000
Construction	120,000	-	120,000
Total	$ 120,000	$ 35,000	$155,000

*Does not include the cost of water rights at Bernon Dam

TABLE D-IV

APPORTIONMENT OF FIRST COSTS BETWEEN
FEDERAL AND NON-FEDERAL INTERESTS
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
SOCIAL DISTRICT UNIT

1. First Costs:

Construction	$2,840,000
Lands & Relocations	560,000
Total	$3,400,000

2. Average Annual Benefits:

Flood Damage Prevention	$114,000	61.3%
Enhancement	72,000	38.7%
Total	$186,000	100.0%

3. Classification of First Costs:

Item	Flood Prevention Portion (61.3%)	Enhancement Portion (38.7%)	Total
Construction	$1,740,000	$1,100,000	$2,840,000
Lands & Relocations	340,000	220,000	560,000
Total First Costs	$2,080,000	$1,320,000	$3,400,000

4. Computation of Non-Federal Share of First Costs:

Item	Tentative Apportionment: Federal Liability	Tentative Apportionment: Non-Federal Liability	Adjustment of Shares to Assign All Lands & Relocations to Non-Federal Interests: Federal Share	Adjustment of Shares to Assign All Lands & Relocations to Non-Federal Interests: Non-Federal Share
Flood Prevention Portion				
Construction	$1,740,000	$ -	$1,740,000	$ -
Lands & Relocations	-	340,000	-	340,000
Total	$1,740,000	$ 340,000	$1,740,000	$ 340,000
Enhancement Portion				
Construction	$ 550,000	$ 550,000	$ 660,000	$ 440,000
Lands & Relocations	110,000	110,000	-	220,000
Total	$ 660,000	$ 660,000	$ 660,000	$ 660,000
Total First Costs				
Construction	$2,290,000	$ 550,000	$2,400,000	$ 440,000*
Lands & Relocations	110,000	450,000	-	560,000
Total	$2,400,000	$1,000,000	$2,400,000	$1,000,000

*This amount of contributed funds is intended for informational purposes only, because it is based on cost estimates prepared for this report and on current price levels, which are both subject to change during detailed design and actual construction.

TABLE D-V

APPORTIONMENT OF FIRST COSTS BETWEEN
FEDERAL AND NON-FEDERAL INTERESTS
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
HAMLET DISTRICT UNIT

1. First Costs:

Construction	$580,000
Lands & Relocations	120,000
Total	$700,000

2. Average Annual Benefits:

Flood Damage Prevention	$17,000	42.5%
Enhancement	23,000	57.5%
Total	$40,000	100.0%

3. Classification of First Costs:

Item	Flood Prevention Portion (42.5%)	Enhancement Portion (57.5%)	Total
Construction	$250,000	$330,000	$580,000
Lands & Relocations	50,000	70,000	120,000
Total First Costs	$300,000	$400,000	$700,000

4. Computation of Non-Federal Share of First Costs:

Item	Tentative Apportionment: Federal Liability	Tentative Apportionment: Non-Federal Liability	Adjustment of Shares to Assign All Lands & Relocations to Non-Federal Interests: Federal Share	Adjustment of Shares to Assign All Lands & Relocations to Non-Federal Interests: Non-Federal Share
Flood Prevention Portion				
Construction	$250,000	$ -	$250,000	$ -
Lands & Relocations	-	50,000	-	50,000
Total	$250,000	$ 50,000	$250,000	$ 50,000
Enhancement Portion				
Construction	$165,000	$165,000	$200,000	$130,000
Lands & Relocations	35,000	35,000	-	70,000
Total	$200,000	$200,000	$200,000	$200,000
Total First Costs				
Construction	$415,000	$165,000	$450,000	$130,000*
Lands & Relocations	35,000	85,000	-	120,000
Total	$450,000	$250,000	$450,000	$250,000

*This amount of contributed funds is intended for informational purposes only, because it is based on cost estimates prepared for this report and on current price levels, which are both subject to change during detailed design and actual construction.

TABLE D-VI

ESTIMATE OF ANNUAL CHARGES
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
SOCIAL DISTRICT UNIT

Federal Investment		
Federal first cost	$2,400,000	
Interest during construction ($2,400,000 @ 2.5%)	60,000	
Total Federal Investment	$2,460,000	
Federal Annual Charges		
Interest ($2,460,000 @ 2.5%)	$ 61,500	
Amortization ($2,460,000 @ 1.026%)	25,200	
Total Federal Annual Charges		$ 86,700
Non-Federal Investment		
Non-Federal first cost	$1,000,000	
Interest during construction ($1,000,000 @ 2.5%)	25,000	
Total Non-Federal Investment	$1,025,000	
Non-Federal Annual Charges		
Interest ($1,025,000 @ 2.5%)	$ 25,600	
Amortization ($1,025,000 @ 1.026%)	10,500	
Maintenance & Operation	5,800	
Interim replacements	1,900	
Net loss of taxes	1,500	
Total Non-Federal Annual Charges		45,300
TOTAL ANNUAL CHARGES		$132,000

TABLE D-VII

ESTIMATE OF ANNUAL CHARGES
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
HAMLET DISTRICT UNIT

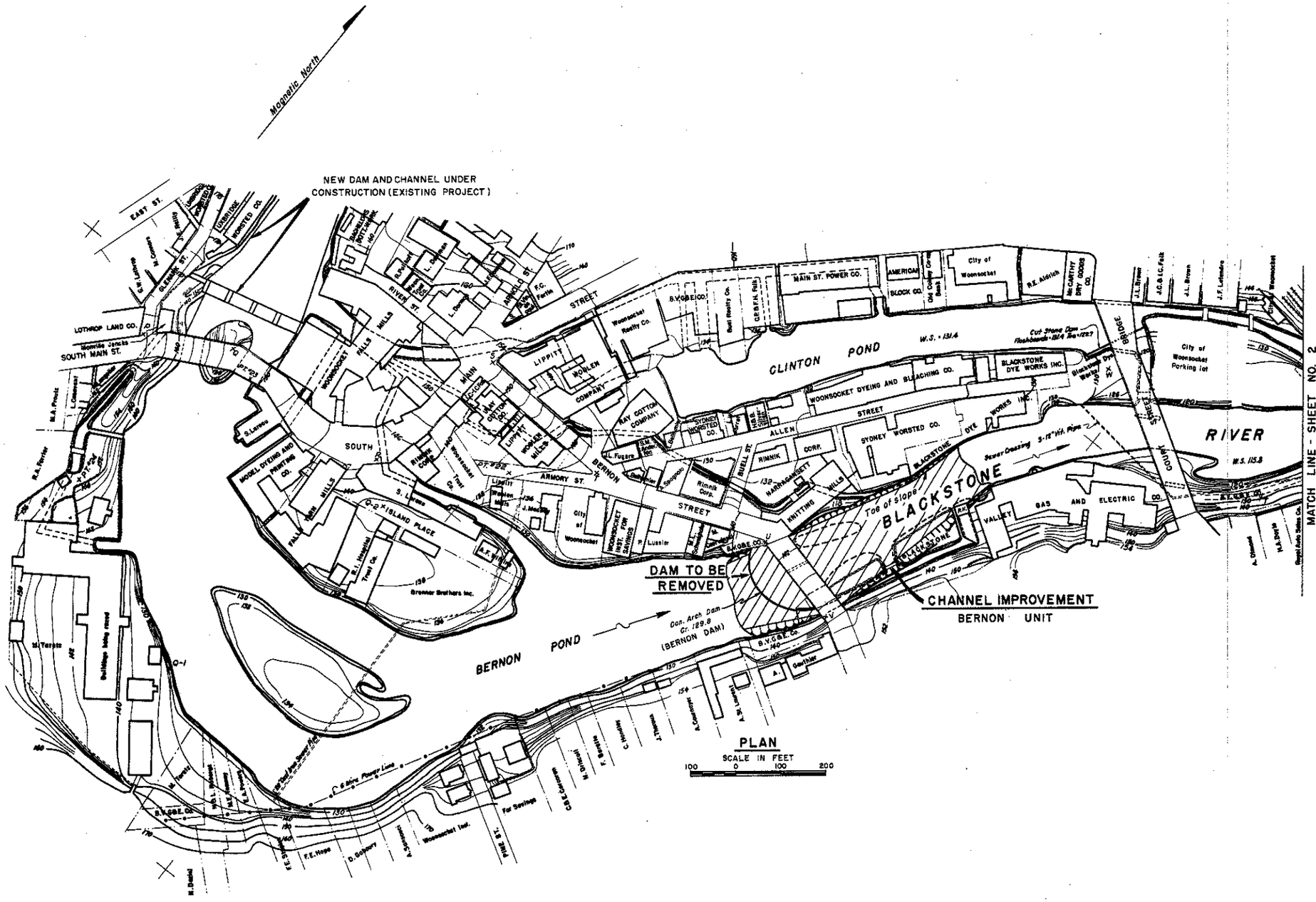
Federal Investment		
Federal first cost	$450,000	
Interest during construction ($450,000 @ 1.25%)	6,000	
Total Federal Investment	$456,000	
Federal Annual Charges		
Interest ($456,000 @ 2.5%)	11,400	
Amortization ($456,000 @ 1.026%)	4,700	
Total Federal Annual Charges		$ 16,100
Non-Federal Investment		
Non-Federal first cost	$250,000	
Interest during construction ($250,000 @ 1.25%)	3,000	
Total Non-Federal Investment	$253,000	
Non-Federal Annual Charges		
Interest ($253,000 @ 2.5%)	$ 6,300	
Amortization ($253,000 @ 1.026%)	2,600	
Maintenance & Operation	2,900	
Interim replacements	1,700	
Net loss of taxes	400	
Total Non-Federal Annual Charges		$ 13,900
TOTAL ANNUAL CHARGES		$ 30,000

TABLE D-VIII

ESTIMATE OF ANNUAL CHARGES
(1956 Price Level)

LOWER WOONSOCKET LOCAL PROTECTION PROJECT
BERNON UNIT

Federal Investment		
Federal first cost	$120,000	
Interest during construction ($120,000 @ 0.625%)	800	
Total Federal Investment	$120,800	
Federal Annual Charges		
Interest ($120,800 @ 2.5%)	$ 3,000	
Amortization ($120,800 @ 1.026%)	1,200	
Total Federal Annual Charges		$ 4,200
Non-Federal Investment		
Non-Federal first cost	$ 35,000	
Interest during construction ($35,000 @ 0.625%)	200	
Total Non-Federal Investment	$ 35,200	
Non-Federal Annual Charges		
Interest ($35,200 @ 2.5%)	$ 900	
Amortization ($35,200 @ 1.026%)	400	
Maintenance & Operation	100	
Interim replacements	-	
Net loss of taxes	200	
Total Non-Federal Annual Charges		$ 1,600
TOTAL ANNUAL CHARGES		$ 5,800



MATCH LINE - SHEET NO. 2

NOTE:

Map data obtained from 1938 Corps of Engineers survey. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY H.S.P. | TR. BY S.F.C. | CK. BY GFB

PROJECT ENGINEER

SUBMITTED BY
CHIEF PLANNING & ESTIMATE BR.

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL., C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND

DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE: AS SHOWN

DRAWING NUMBER
BE-1-1185

SHEET 1 OF 5

PLATE NO. D-1

CORPS OF ENGINEERS

U. S. ARMY

MATCH LINE SHEET 4

MATCH LINE SHEET NO. 1

MATCH LINE SHEET 5

MATCH LINE SHEET 3

WORRAL STREET

AMERICAN WRINGER CO.

POND STREET

COLLIER STREET

NOURSE STREET

SAMPSON STREET

PAGE STREET

SOCIAL STREET

CLINTON STREET

DIKE

CONDUIT HEADWALL

PRESSURE CONDUIT

SUPERMARKET

ELBOW STREET

Abandoned tailrace

GOBEILLE AVE.

RATHBUN ST.

MILL RIVER

BROOK ST.

CUMBERLAND STREET

GIRARD AVE.

WOONSOCKET FALLS MILL (CLINTON MILL)

BLACKSTONE VALLEY GAS & ELECTRIC COMPANY

DIKE
SOCIAL DISTRICT UNIT

WOONSOCKET RAYON CO.

Gr = 127±

Gr = 133.8±

Gr = 126.5±

Gr = 125±

BLACKSTONE RIVER

(GAS WORKS)

BLACKSTONE VALLEY GAS & ELECTRIC CO. (RIVERSIDE SUB-STATION)

CONCRETE DAM TO BE REMOVED

HAMLET DAM

CONC. PLATFORM EL. 124.8

Toe of slope

CHANNEL IMPROVEMENT
SOCIAL DISTRICT UNIT

PUMPING STATION

PETERS RIVER

PRESSURE CONDUIT

HAMLET TRENCH

Top of slope

FLOODWALL
SOCIAL DISTRICT UNIT

LOCUST ST.

PROVIDENCE & WORCESTER R.R. (N.Y., N.H. & H. R.R.)

WEST PARK PLACE

PARK PLACE

PLAN
SCALE IN FEET
100 0 100 200

DIKE
HAMLET DISTRICT UNIT

CONSOLIDATED PRINT CO.

FLOODWALL
HAMLET DISTRICT UNIT

FOOT BRIDGE

VILLANOVA STREET

KENDRICK AVE.

GROVE STREET

HAMLET AVE

HARRISON AVE.

BELLEVUE AVE.

MORTON AVE.

CARRINGTON AVE.

WELLES STREET

VERDUN WORSTED COMPANY

FLORENCE DYE WORKS

FLORENCE DRIVE

DIKE
HAMLET DISTRICT UNIT

LEGEND

X 123.2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

APPROXIMATE LOCATION OF BLACKSTONE VALLEY GAS & ELECTRIC CO. POWER LINE TOWER

NOTES

Map data obtained from 1890 and 1914 assessment maps and 1938 Corps of Engineers survey. Data field checked in 1956

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR BY	TR BY	CK BY
H.S.P.	S.F.C.	GFB

PROJECT ENGINEER

SUBMITTED BY
CHIEF, LANDS & RESERVOIRS BRANCH

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
GENERAL PLAN
BLACKSTONE, MILL & PETERS RIVERS, R.I.

DATE FEB. 1957

TO ACCOMPANY REPORT DATED 29 MAY 1957

SCALE: AS SHOWN

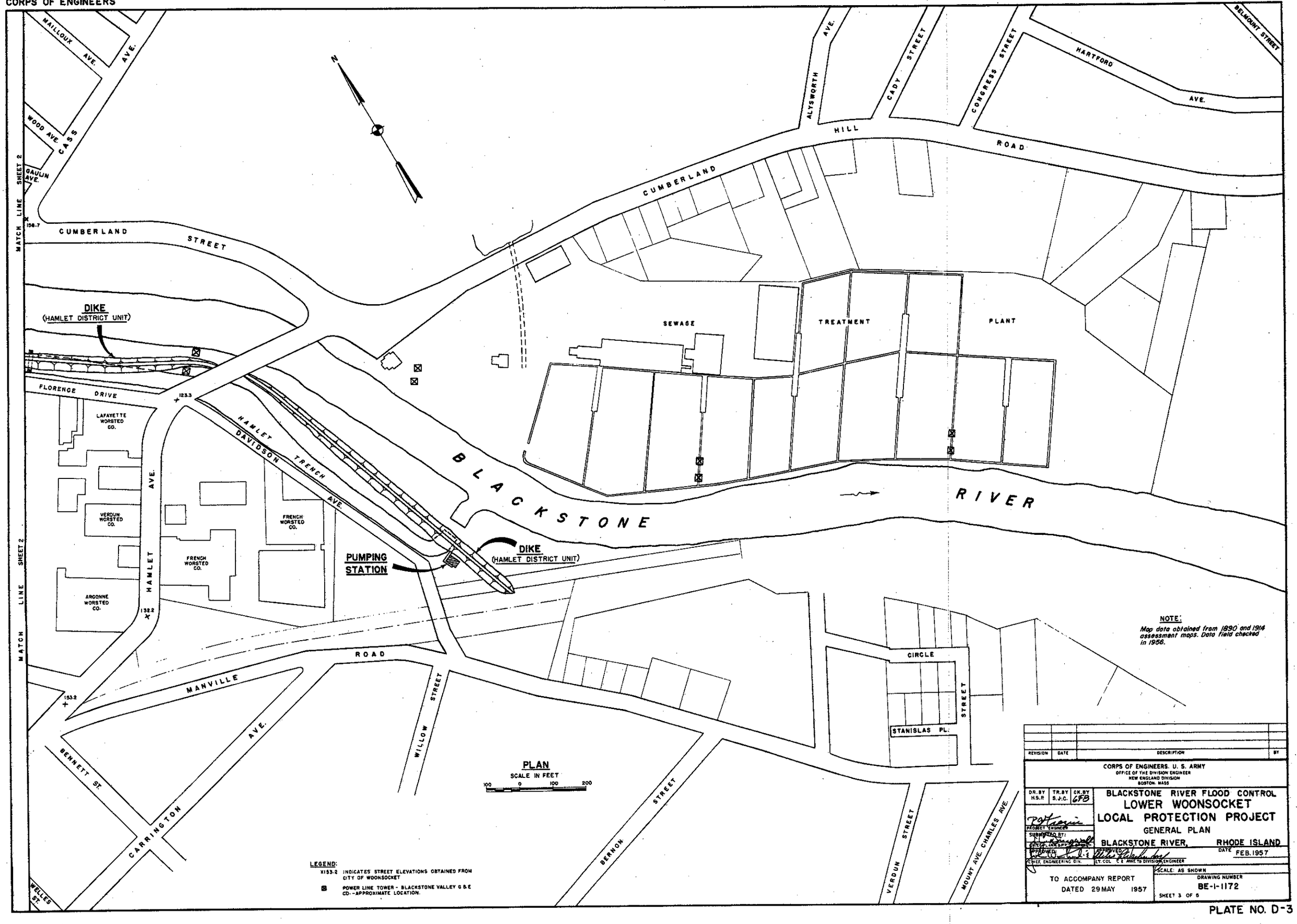
DRAWING NUMBER
BE-1-1171

SHEET 2 OF 5

PLATE NO. D-2

CORPS OF ENGINEERS

U.S. ARMY



NOTE:
Map data obtained from 1890 and 1914 assessment maps. Data field checked in 1956.

LEGEND:

X153-2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

POWER LINE TOWER - BLACKSTONE VALLEY G.&E. CO. - APPROXIMATE LOCATION.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
H.S.R	S.J.C.	GFB

PROJECT ENGINEER

SUBMITTED BY:
CHIEF, PLANNING BRANCH

APPROVED:
CHIEF, ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

DATE FEB. 1957

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE: AS SHOWN

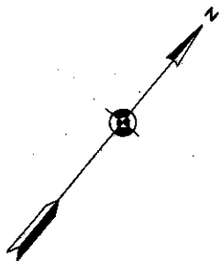
DRAWING NUMBER
BE-1-1172

SHEET 3 OF 5

PLATE NO. D-3

CORPS OF ENGINEERS

U.S. ARMY



PLAN

SCALE IN FEET

100 0 100 200

LEGEND

X 138.2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

NOTES

Map data obtained from 1914 assessment maps. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
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PROJECT ENGINEER

SUBMITTED BY

CHIEF, ENGINEERING DIV.

APPROVED

LT. COL. C.E., ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
GENERAL PLAN
MILL RIVER, RHODE ISLAND

DATE FEB. 1957

SCALE: AS SHOWN

TO ACCOMPANY REPORT
DATED 29 MAY 1957

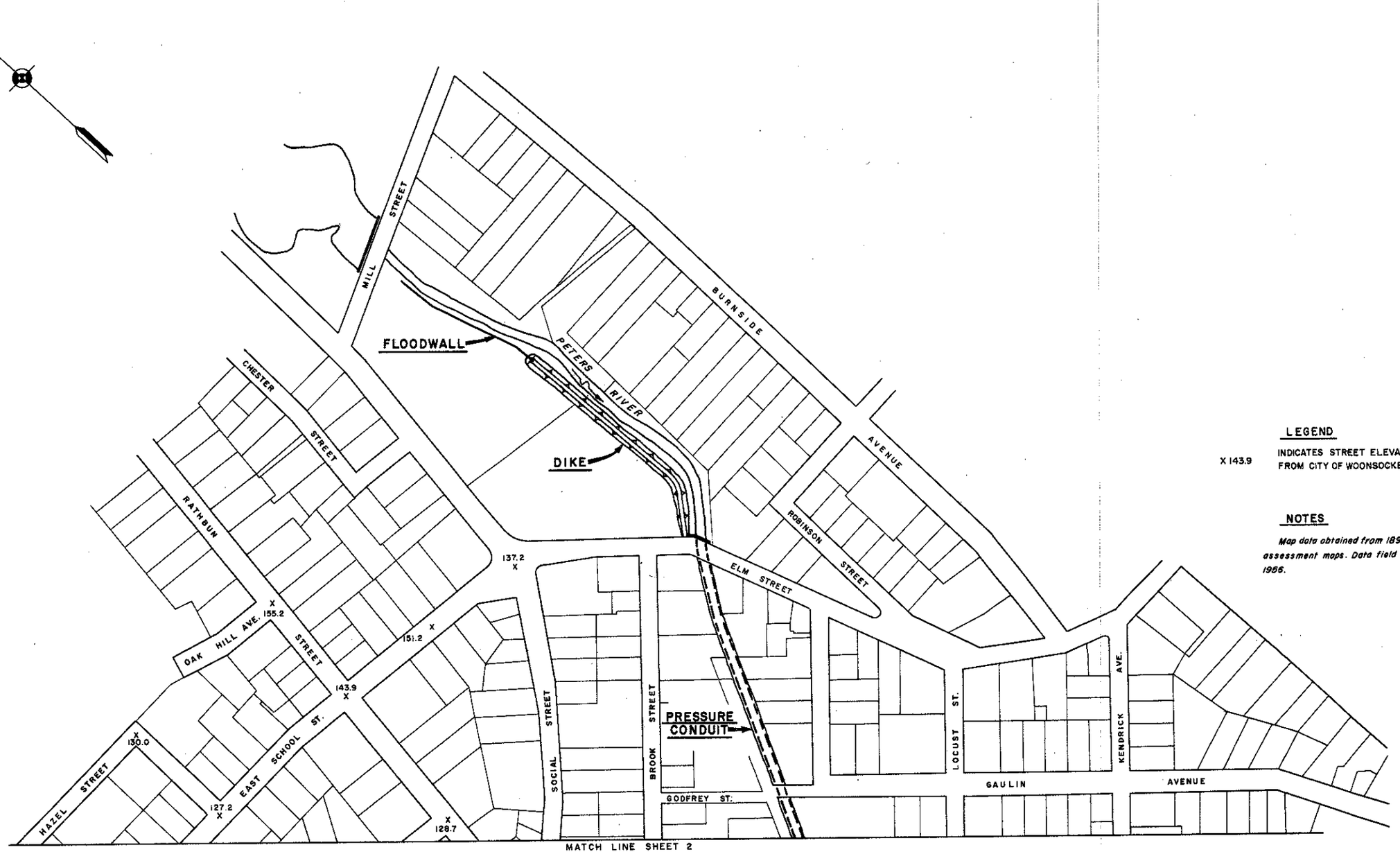
DRAWING NUMBER
BE-1-1173

SHEET 4 OF 5

PLATE NO. D-4

CORPS OF ENGINEERS

U. S. ARMY



PLAN

SCALE IN FEET

100 0 100 200

LEGEND

X 143.9 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

NOTES

Map data obtained from 1890 and 1914 assessment maps. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY	TR. BY	CK. BY
H.S.P.	S.F.C.	GFB

PROJECT ENGINEER

SUBMITTED BY
CHIEF PLANS & REPORTS BRANCH

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E., ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
GENERAL PLAN
PETERS RIVER, RHODE ISLAND

DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE: AS SHOWN

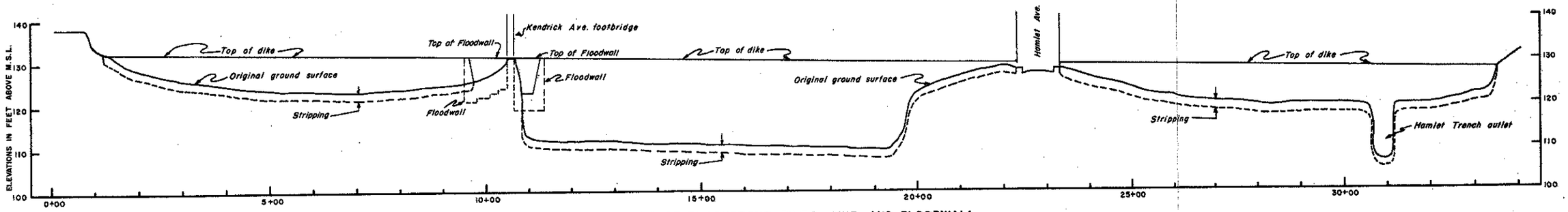
DRAWING NUMBER
BE-1-1174

SHEET 8 OF 5

PLATE NO. D-5

CORPS OF ENGINEERS

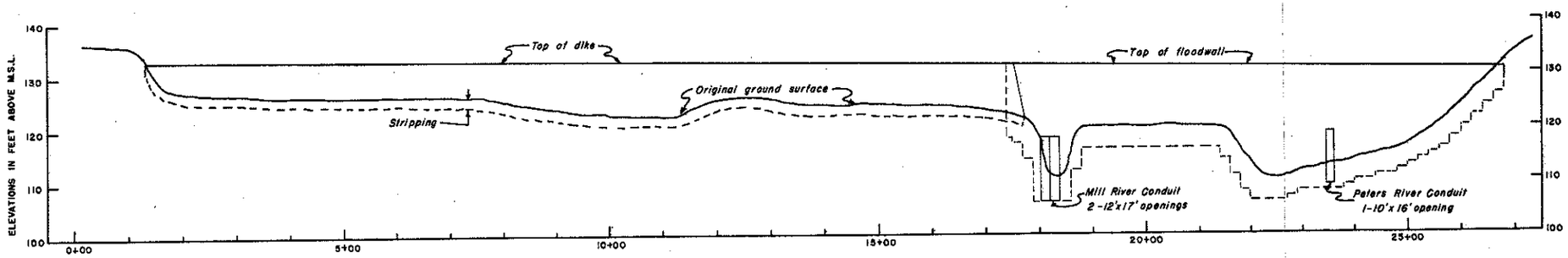
U. S. ARMY



PROFILE OF BLACKSTONE RIVER DIKE AND FLOODWALL

HAMLET DISTRICT UNIT

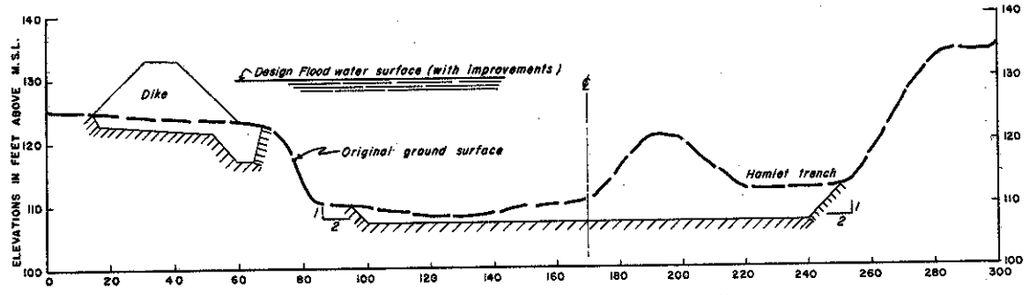
SCALE HOR. 1" = 100'
VERT. 1" = 10'



PROFILE OF BLACKSTONE RIVER DIKE AND FLOODWALL

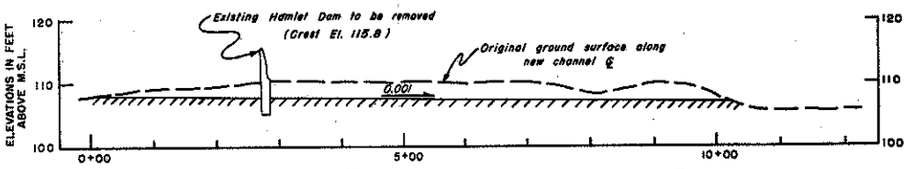
SOCIAL DISTRICT UNIT

SCALE HOR. 1" = 100'
VERT. 1" = 10'



TYPICAL BLACKSTONE RIVER CHANNEL SECTION

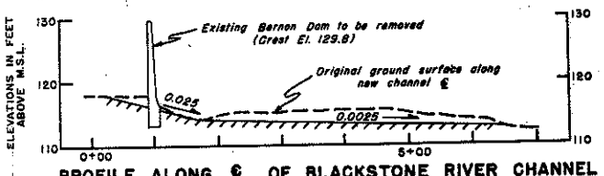
SCALE HOR. 1"=20'
VERT. 1"=10'



PROFILE ALONG ℄ OF BLACKSTONE RIVER CHANNEL

SOCIAL DISTRICT UNIT

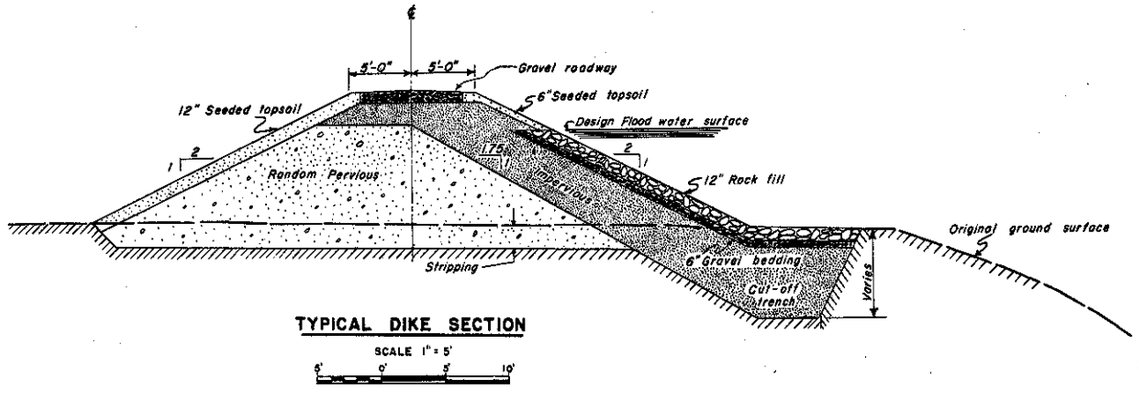
SCALE HOR. 1" = 100'
VERT. 1" = 10'



PROFILE ALONG ℄ OF BLACKSTONE RIVER CHANNEL

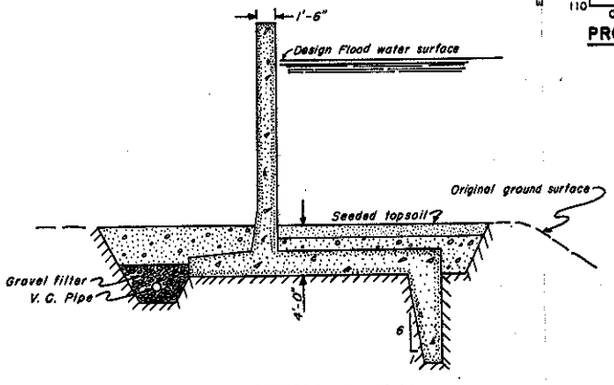
BERNON UNIT

SCALE HOR. 1" = 100'
VERT. 1" = 10'



TYPICAL DIKE SECTION

SCALE 1" = 5'



TYPICAL FLOODWALL SECTION

SCALE 1" = 5'

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY	TR. BY	CK. BY
H.S.P.	R.G.C.	GPB

PROJECT ENGINEER

SUBMITTED BY
CHIEF PLANS AND DESIGN BRANCH

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
PROFILES AND SECTIONS
BLACKSTONE RIVER, RHODE ISLAND

DATE FEB. 1957

SCALE AS SHOWN

TO ACCOMPANY REPORT
DATED 29 MAY 1957

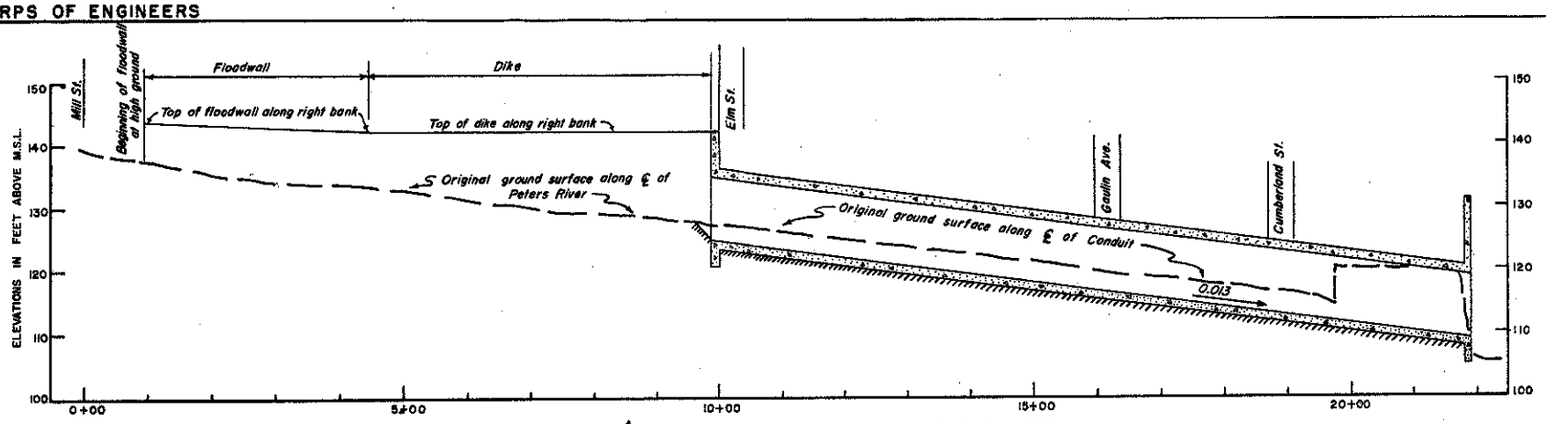
DRAWING NUMBER
BE-4-1175

SHEET 1 OF 2

PLATE NO. D-6

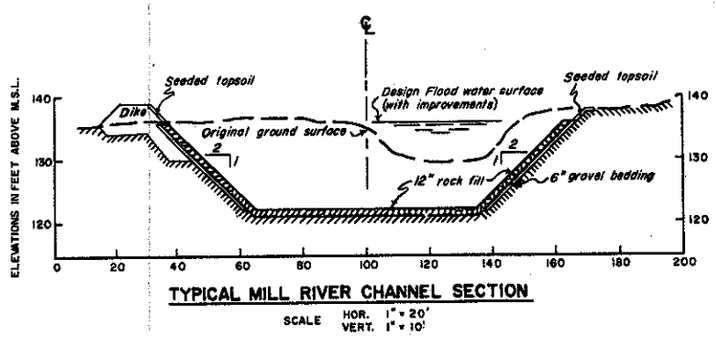
CORPS OF ENGINEERS

U.S. ARMY



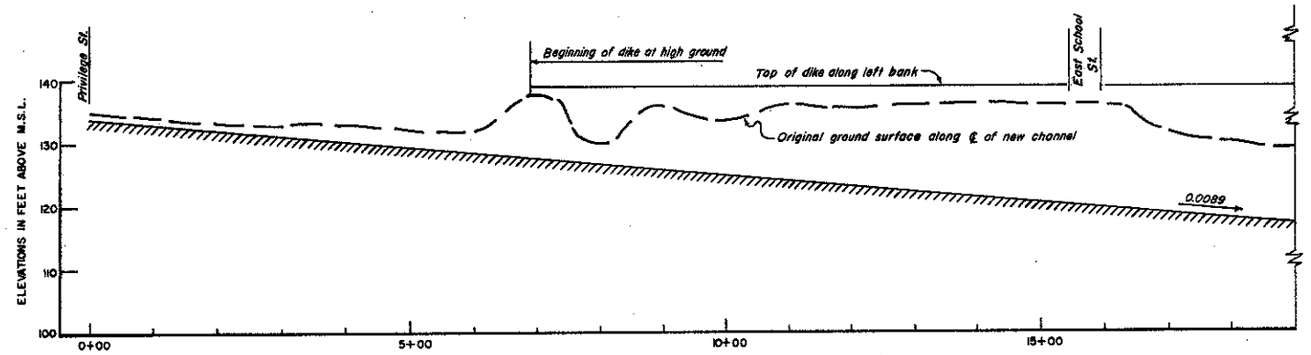
PROFILE ALONG ℄ OF PETERS RIVER CHANNEL AND CONDUIT

SCALE HOR. 1"=100'
VERT. 1"=10'



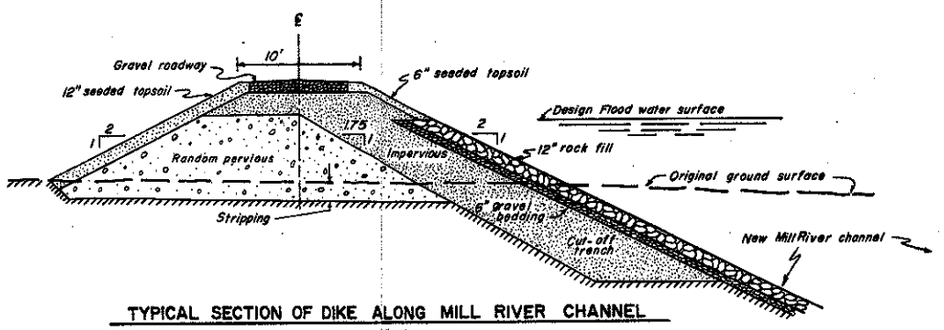
TYPICAL MILL RIVER CHANNEL SECTION

SCALE HOR. 1" = 20'
VERT. 1" = 10'



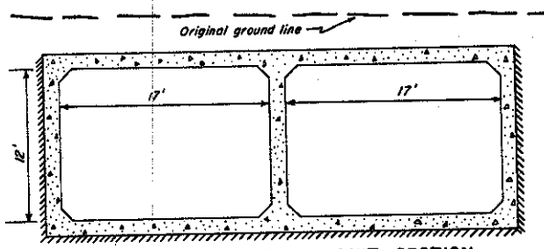
PROFILE ALONG ℄ OF MILL RIVER CHANNEL AND CONDUIT

SCALE HOR. 1"=100'
VERT. 1"=10'



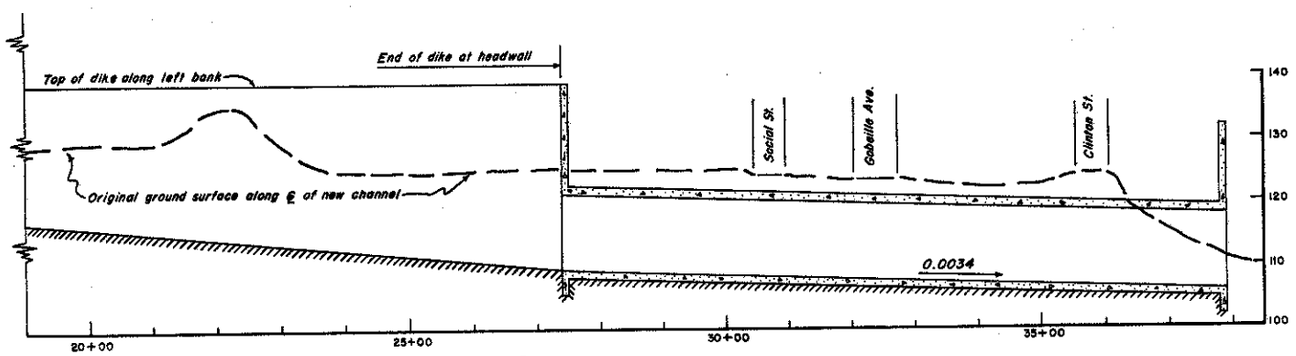
TYPICAL SECTION OF DIKE ALONG MILL RIVER CHANNEL

SCALE 1"=5'



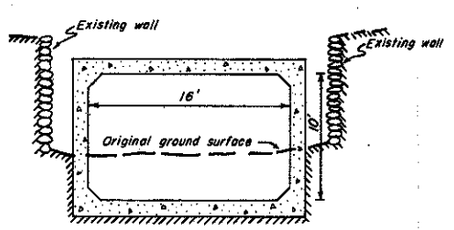
TYPICAL MILL RIVER CONDUIT SECTION

SCALE 1" = 5'



PROFILE ALONG ℄ OF MILL RIVER CHANNEL AND CONDUIT

SCALE HOR. 1"=100'
VERT. 1"=10'



TYPICAL PETERS RIVER CONDUIT SECTION

SCALE 1"=5'

5' 0 5' 10

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR BY	TR BY	CK BY
H.S.P.	S.J.C.	GFB

PROJECT ENGINEER

SUBMITTED BY
CHIEF PLANS GROUP

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
LOCAL PROTECTION PROJECT
PROFILES AND SECTIONS
MILL AND PETERS RIVERS, RHODE ISLAND

DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE AS SHOWN

DRAWING NUMBER
BE-1-1176

SHEET 2 OF 2

PLATE NO. D-7

APPENDIX E

ADDITIONAL PLANS STUDIED

APPENDIX E

ADDITIONAL PLANS STUDIED

TABLE OF CONTENTS

PLATES

APPENDIX E

ADDITIONAL PLANS STUDIED

E1. GENERAL

Several additional flood control plans were studied for the protection of Lower Woonsocket. These plans consist of (1) seven dike and floodwall units at locations other than those included in the recommended Lower Woonsocket Local Protection Project; (2) a general improvement of the Blackstone River channel; and (3) upstream reservoirs on the tributary Mill and Peters Rivers. Economic analyses revealed that annual charges would exceed annual benefits for each of these plans. All first costs, annual charges, and annual losses and benefits cited in this appendix are estimated at the 1956 price level.

E2. DIKES AND FLOODWALLS

E2.1 General.- Seven supplemental dike and floodwall units were studied in addition to those recommended in the Lower Woonsocket Local Protection Project. Four of these units are located on the left bank of the Blackstone River and three on the right bank. Each of the seven areas considered would benefit by reductions afforded by operation of the authorized West Hill Reservoir; therefore, cost computations for dikes and floodwalls are based on units which would provide adequate protection against standard project flood flows modified by operation of West Hill Reservoir. In each case the annual costs would exceed the annual benefits and a reduction in the height of dikes and floodwalls would not provide justifiable economic protection against a lesser flood.

The following paragraphs discuss the location, size, and economic evaluation of each unit, and protection which would be afforded these areas by the authorized West Hill Reservoir and by other improvements. The lack of economic justification for each of the dike and floodwall units is shown by comparison of annual charges to annual losses remaining in the area after operation of West Hill Reservoir.

E2.1 Unit No. 1.- This unit would consist of approximately 875 feet of earth dike and 700 feet of concrete floodwall to protect an industrial area on the left bank of the Blackstone River between the South Main Street and Bernon Street bridges. The total estimated first cost is $465,000. Resulting annual charges of $18,000 for a unit to protect an area with annual residual losses of $13,700, after reduction by West Hill Reservoir, precludes economic justification. However, the Bernon Unit of the recommended project and West Hill Reservoir would provide substantial protection for this area.

E2.3 Unit No. 2.- Protection for an industrial and commercial area on the left bank of the Blackstone River between Bernon Street and Court Street bridges would require about 1,000 feet of concrete floodwall and a pumping station to discharge interior drainage. The estimated total first cost is $790,000. Resulting annual charges of $32,000 for a unit to protect an area with annual residual losses of $13,800, after West Hill reductions, precludes economic justification. Partial protection for the area would be provided by West Hill Reservoir, by removal of Hamlet Dam and channel excavation as part of the recommended plan, and by the Bernon Unit which is also a part of the recommended plan.

E2.4 Unit No. 3.- Approximately 650 feet of concrete floodwall along the left bank of the Blackstone River a short distance upstream from Hamlet Dam would be needed to protect the Clinton Mill. The total estimated first cost is $305,000. Resulting annual charges of $12,000 for a unit to protect an area with annual residual losses of $2,400, after reduction by West Hill Reservoir, precludes economic justification. This property would be partially protected, however, by West Hill Reservoir and by removal of Hamlet Dam and channel excavation as part of the recommended plan.

E2.5 Unit No. 4.- A unit consisting of 550 feet of earth dike, 2,250 feet of concrete floodwall, and a pumping station would be required to protect the city's sewage treatment plant. The plant is located on the left bank of the Blackstone River downstream from Hamlet Avenue bridge. The total estimated first cost amounts to $770,000. Resulting annual charges of $31,000 for a unit to protect an area with annual residual losses of $1,100, after West Hill reductions, precludes economic justification. The treatment plant would be afforded partial protection by West Hill Reservoir.

E2.6 Unit No. 5.- Approximately 650 feet of concrete floodwall would be required to protect the Blackstone Valley Gas and Electric Company's No. 1 Station, located on the right bank of the Blackstone River immediately upstream from Court Street bridge. This station supplies electric service to a part of Woonsocket. The total estimated first cost is $340,000. Resulting annual charges of $13,500 for a unit to protect an area with annual residual losses of $1,200, after West Hill reductions, precludes economic justification. This proerty, however, would be afforded partial protection by West Hill Reservoir and by removal of Hamlet Dam and channel excavation as part of the recommended plan.

E2.7 Unit No. 6.- Protection for the Blackstone Valley Gas and Electric Company's gas works would require approximately 200 feet of concrete floodwall along the right bank of the Blackstone River immediately downstream

from Court Street bridge. The total estimated first cost is $80,000. Resulting annual charges of $3,500 for a unit to protect an area with residual losses of less than $1,000, after West Hill reductions, precludes economic justification. Partial protection would be afforded, however, by West Hill Reservoir and by removal of Hamlet Dam and channel excavation as part of the recommended plan.

E2.8 Unit No. 7.- Approximately 900 feet of concrete floodwall would be required for the protection of the Blackstone Valley Gas and Electric Company's Riverside Substation. This substation, located on the right bank of the Blackstone River upstream from Hamlet Dam, is the central point of electric power distribution for the Woonsocket area. The total estimated first cost of the unit is $220,000. Resulting annual charges of $8,500 for a unit to protect an area with annual residual losses of less than $1,000, after West Hill reductions, precludes economic justification. This substation, however, would be afforded partial protection by West Hill Reservoir and by removal of Hamlet Dam and channel excavation as part of the recommended plan.

E3. GENERAL CHANNEL IMPROVEMENT

The general channel improvement plan would provide for widening and deepening the Blackstone River for a distance of approximately 10,400 feet from a point near the downstream side of South Main Street bridge to a point near the lower end of the sewage treatment plant. The new channel would have a bottom width of 150 feet, except where existing developments require a narrower width. This plan would also include the removal of Hamlet and Bernon Dams as well as the Kendrick Avenue footbridge. The total estimated first cost is $2,100,000. Annual charges are estimated at $83,000. Benefits, computed as incremental to those assigned to the authorized West Hill Reservoir, would amount to $77,300, resulting in a benefit-cost ratio of 0.9 to 1.0. A plan of this channel improvement is shown on Plates E-4 through E-6.

Reductions in flood stages by means of channel improvement are limited due to the flat slopes of flood profiles in this area. In a flood of August 1955 magnitude, stage reductions would amount to 1½ feet at the Woonsocket gaging station. The removal of Manville Dam and the highway bridge immediately below the dam in the village of Manville, 2.8 miles downstream from Hamlet Avenue bridge in Woonsocket, was also considered during the course of channel improvement studies. Hydraulic studies revealed, however, that the removal of these structures would have a negligible effect on flood stages in the Lower Woonsocket area.

Partial protection in a portion of the survey area would be provided by the removal of Bernon Dam and Hamlet Dam with contiguous channel excavation. These two features are include as part of the recommended plan which is presented in Appendix D.

E4. RESERVOIRS

E4.1 General.- Two flood control reservoirs were studied for the protection of the Lower Woonsocket area. These are Pine Hill Reservoir on the Mill River and Bellingham Reservoir on the Peters River. Both tributaries join the Blackstone River in the Lower Woonsocket area. The reservoirs are described further in the following paragraphs, and reservoir maps are shown on Plates E-7 and E-8.

E4.2 Pine Hill Reservoir.- Pine Hill Dam would be located on the Mill River in the Town of Blackstone, Massachusetts, 4 miles north of Woonsocket. The dam would be a rolled earth-fill structure with a length of 750 feet and a maximum height of 50 feet above streambed. Reservoir overflows would discharge through a spillway channel located in a natural saddle 600 feet east of the dam. The dam would impound a reservoir about 3.75 miles long, with a flood control storage capacity of 11,200 acre feet. This storage capacity is equivalent to 8.3 inches of runoff from the drainage area of 25.3 square miles at the dam site.

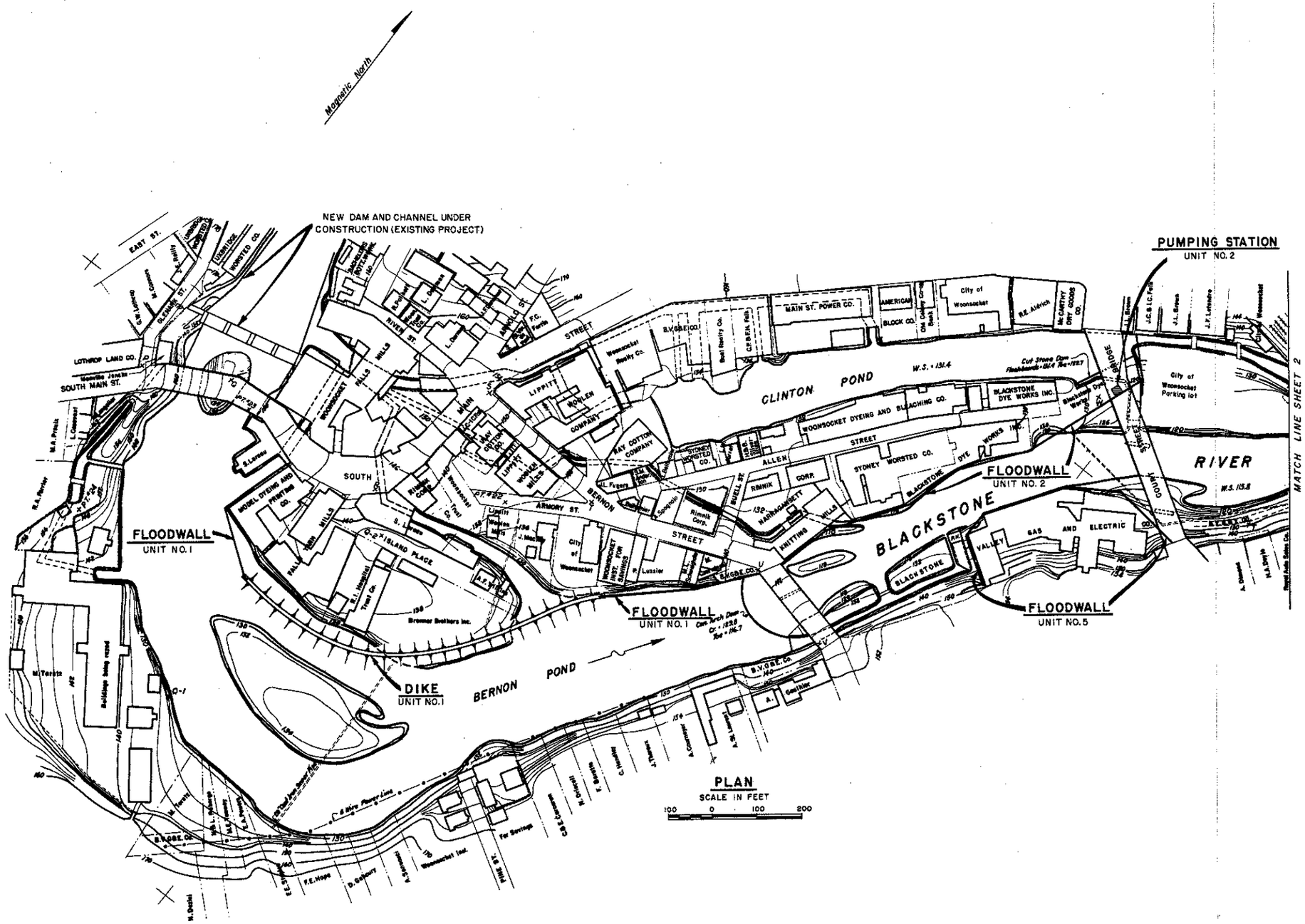
During major floods the Mill River peak discharge at Woonsocket precedes that of the Blackstone River by approximately 13 hours. Operation of this reservoir would reduce the peak stage of the standard project flood on the Blackstone River in Woonsocket by $\frac{1}{2}$ foot at the U.S.G.S. gaging station, located a short distance downstream from the confluence of the Mill and Blackstone Rivers.

The total estimated first cost of the project is $1,900,000. Annual charges are estimated at $85,800. Flood-prevention benefits, computed as incremental to those assigned to the authorized West Hill Reservoir, would amount to $74,600 annually, resulting in a benefit-cost ratio of 0.9 to 1.0.

Combining this reservoir with the recommended Lower Woonsocket Local Protection Project was considered in order to evaluate the effect on the size of dikes, channel, and pressure conduit required to contain Mill River flood discharges in Woonsocket. However, the net increase in the cost of the combined projects over the recommended plan was found to exceed the increase in benefits.

E4.3 Bellingham Reservoir.- Bellingham Dam would be located on the Peters River in the Town of Bellingham, Massachusetts, 2 miles northeast of Woonsocket. The dam would be a rolled earth-fill structure with a length of 800 feet and a maximum height of 26 feet above streambed. Reservoir overflows would discharge through a spillway channel 100 feet north of the dam. The dam would create a reservoir about 1.8 miles long, with a flood control storage capacity of 2,200 acre-feet. This storage capacity is equivalent to 6.6 inches of runoff from the drainage area of 6.3 square miles at the dam site.

This project was discarded because it would effect negligible reductions in flood stages at Lower Woonsocket and at other downstream damage points. Combining this reservoir with the recommended Lower Woonsocket Local Protection Project was considered in order to evaluate the effect on the size of the pressure conduit required to contain Peters River flood discharges in Woonsocket. This effect was found to be negligible.



NOTES:

Map data obtained from 1938 Corps of Engineers survey. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS.

DR. BY	TR. BY	CK. BY
H.S.P.	S.F.C.	GFD

PROJECT ENGINEER

SUBMITTED BY
CHIEF, PLANS SECTION

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CHIEF ENGINEERING DIV.

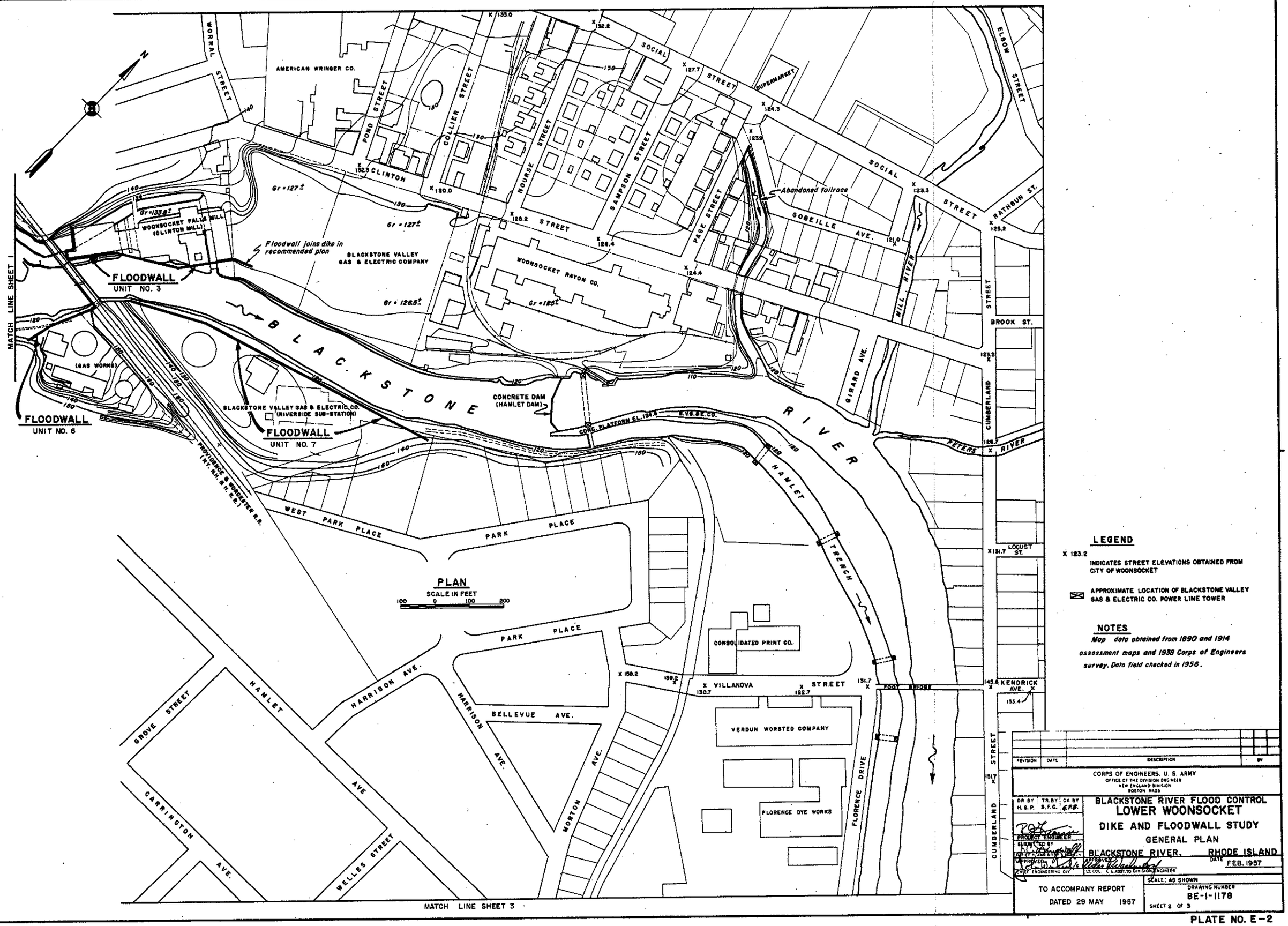
APPROVED
LT. COL. C.E., ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
DIKE AND FLOODWALL STUDY
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND
DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE: AS SHOWN
DRAWING NUMBER
NE-1-1177
SHEET 1 OF 3

PLATE NO. E-1



LEGEND

X 123.2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

APPROXIMATE LOCATION OF BLACKSTONE VALLEY GAS & ELECTRIC CO. POWER LINE TOWER

NOTES

Map data obtained from 1890 and 1914 assessment maps and 1938 Corps of Engineers survey. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR BY H.S.P. | TR. BY S.F.C. | CK BY F.F.B.

PROJECT ENGINEER

SUBMITTED BY
CHIEF, P. AND R. BRANCH

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
DIKE AND FLOODWALL STUDY
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND

DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE: AS SHOWN

DRAWING NUMBER
BE-1-1178

SHEET 2 OF 3

PLATE NO. E-2

MAILLOUX AVE.

AVE.

WOOD AVE.

CASS

GAULIN AVE.

MATCH LINE SHEET 2

136.7

CUMBERLAND STREET

FLORENCE DRIVE

133.3

LAFAYETTE WORSTED CO.

HAMLET AVE.

VERDUN WORSTED CO.

FRENCH WORSTED CO.

FRENCH WORSTED CO.

ARGONNE WORSTED CO.

132.8

HAMLET DAVIDSON TRENCH AVE.

MANVILLE ROAD

133.2

BENNETT ST.

CARRINGTON AVE.

WELLES ST.

WILLOW STREET

BERNON STREET

VERDUN STREET

MOUNT ST. CHARLES AVE.

CIRCLE

STANISLAS PL.

STREET

CUMBERLAND HILL ROAD

ALYSWORTH AVE.

CADY STREET

CONGRESS STREET

HARTFORD AVE.

BELMONT STREET

SEWAGE TREATMENT PLANT

PRESSURE CONDUIT
UNIT NO. 4

FLOODWALL
UNIT NO. 4

DIKE
UNIT NO. 4

PUMPING STATION
UNIT NO. 4

BLACKSTONE RIVER

N

PLAN
SCALE IN FEET
100 0 100 200

LEGEND:
X153.2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

POWER LINE TOWER - BLACKSTONE VALLEY G&E CO. - APPROXIMATE LOCATION.

NOTE
Map data obtained from 1890 and 1924 assessment maps. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
N.S.P.	S.J.C.	GFB

PROJECT ENGINEER
SUBMITTED BY:
CHIEF, ADVANCE ENGINEERING BRANCH
APPROVED:
CHIEF ENGINEERING DIV.
APPROVED:
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
DIKE AND FLOODWALL STUDY
GENERAL PLAN

BLACKSTONE RIVER, RHODE ISLAND

DATE FEB. 1957

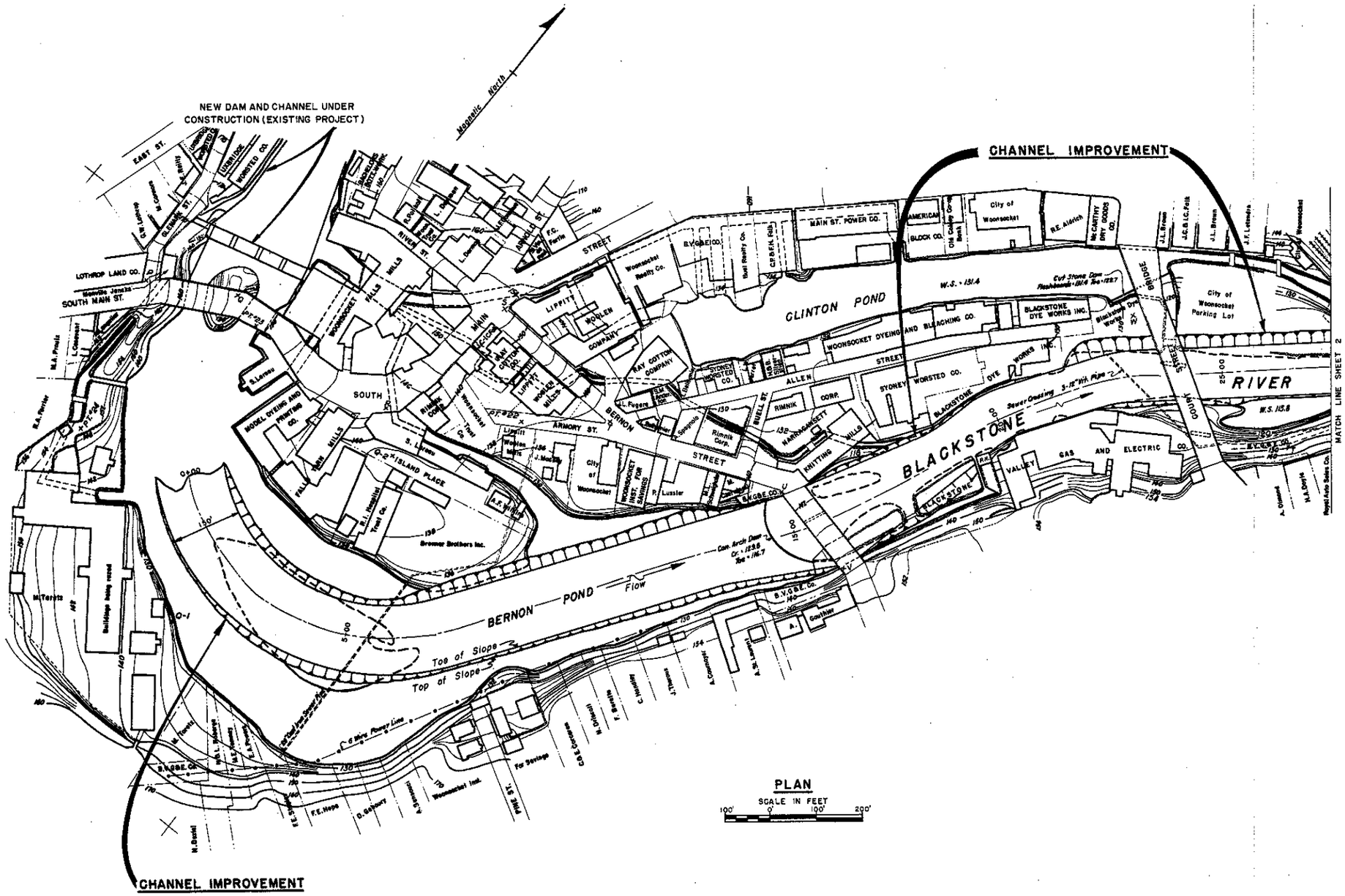
SCALE: AS SHOWN

DRAWING NUMBER
BE-1-1179

SHEET 3 OF 3

TO ACCOMPANY REPORT
DATED 29 MAY 1957

PLATE NO. E-3



PLAN
SCALE IN FEET
100' 0' 100' 200'

NOTE

Map data obtained from 1938 Corps of Engineers survey. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS.

DR. BY	TR. BY	CK. BY
H. S. R	R.G.C.	GFB

PROJECT ENGINEER

SUBMITTED BY
CHIEF PLANNING & REPORTS BRANCH

APPROVED
CHIEF ENGINEERING DIV.

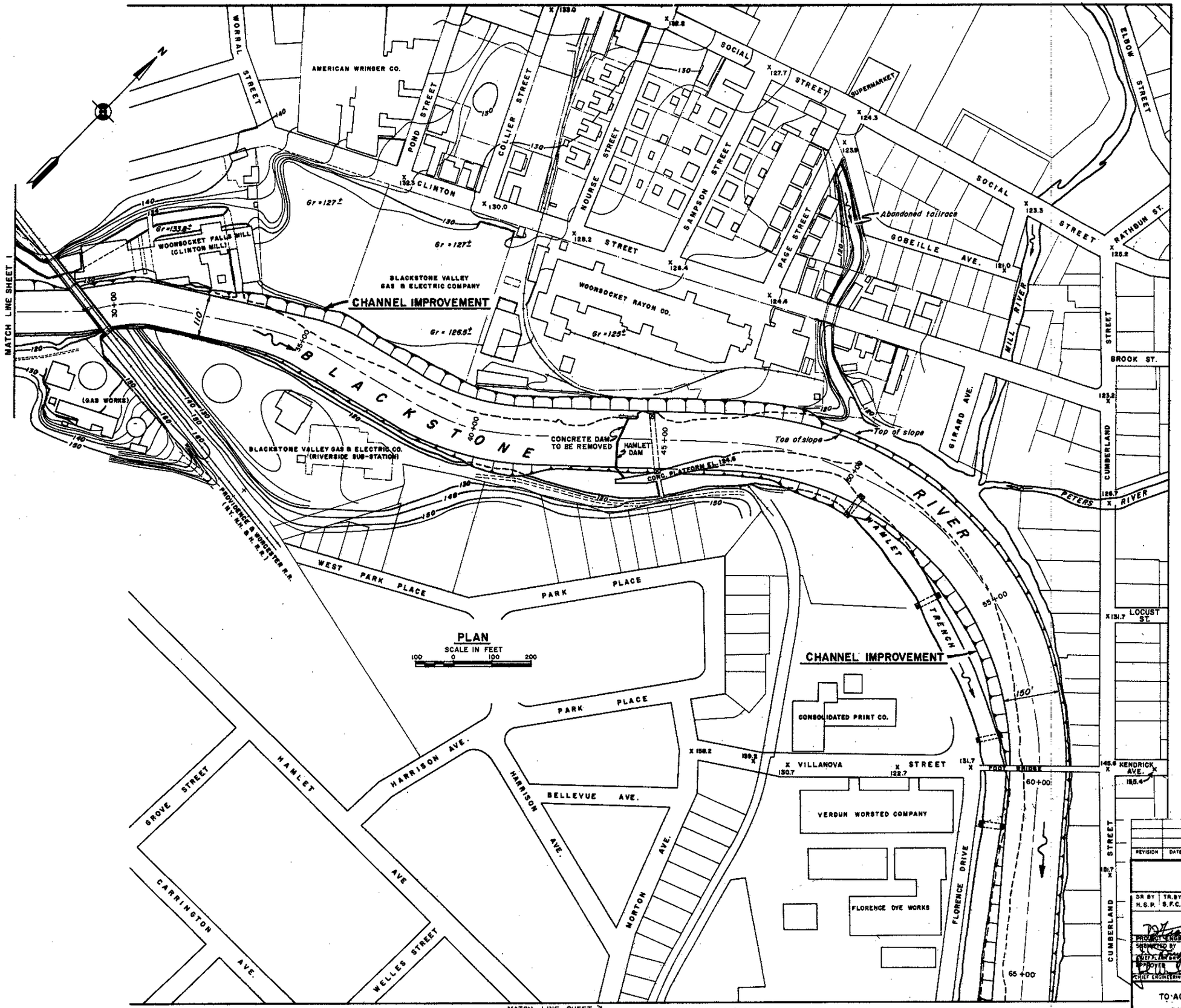
APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
CHANNEL IMPROVEMENT STUDY
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND
DATE FEB. 1957

TO ACCOMPANY REPORT
DATED 29 MAY 1957

SCALE AS SHOWN
DRAWING NUMBER
BE-1-1180
SHEET 1 OF 3

PLATE NO. E-4



LEGEND

X 123.2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

APPROXIMATE LOCATION OF BLACKSTONE VALLEY GAS & ELECTRIC CO. POWER LINE TOWER

NOTES

Map data obtained from 1890 and 1914 assessment maps and 1938 Corps of Engineers survey. Data field checked in 1956.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY H.G.P. | TR. BY B.F.C. | CK. BY GFD

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
CHANNEL IMPROVEMENT STUDY
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND

PROJECT ENGINEER
SUBMITTED BY
CHIEF, ENGINEERING DIV.
APPROVED
CHIEF ENGINEERING DIV.
APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER
DATE FEB. 1957

TO ACCOMPANY REPORT DATED 29 MAY 1957

SCALE: AS SHOWN
DRAWING NUMBER NE-1-1181
SHEET 2 OF 3

PLATE NO. E-5

CORPS OF ENGINEERS

U.S. ARMY

MATCH LINE SHEET 2

MAILLOUX AVE.

WOOD AVE.

CASS AVE.

GAULIN AVE.

X 150.7

CUMBERLAND STREET

CHANNEL IMPROVEMENT

Top of Slope

Toe of Slope

70+00

150'

FLORENCE DRIVE

X 123.3

LAFAYETTE WORSTED CO.

VERDUN WORSTED CO.

HAMLET AVE.

HAMLET DAVIDSON TRENCH AVE.

FRENCH WORSTED CO.

FRENCH WORSTED CO.

ARGONNE WORSTED CO.

X 138.2

CUMBERLAND HILL ROAD

ALYSWORTH AVE.

CADY STREET

CONGRESS STREET

HARTFORD AVE.

BELMONT STREET

SEWAGE TREATMENT PLANT

75+00

80+00

BLACKSTONE RIVER

85+00

90+00

95+00

150'

CHANNEL IMPROVEMENT

Toe of Slope

Top of Slope

NOTE

Map data obtained from 1890 and 1914 assessment maps. Data field checked in 1956.

MANVILLE ROAD

X 133.2

BENNETT ST.

CARRINGTON AVE.

WELLES ST.

WILLOW STREET

CIRCLE

STANISLAS PL.

STREET

BERNON STREET

VERDUN STREET

MOUNT ST. CHARLES AVE.

PLAN

SCALE IN FEET

100' 0 100' 200'

LEGEND:

X153.2 INDICATES STREET ELEVATIONS OBTAINED FROM CITY OF WOONSOCKET

POWER LINE TOWER - BLACKSTONE VALLEY G & E CO. - APPROXIMATE LOCATION.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY H.S.R | TR. BY S.J.C. | CK. BY G.T.B.

PROJECT ENGINEER

SUBMITTED BY: CHIEF, PLANNING BRANCH

APPROVED: CHIEF ENGINEERING DIV.

APPROVED: LT. COL. C. E. ACTING DIVISION ENGINEER

DATE FEB. 1957

BLACKSTONE RIVER FLOOD CONTROL
LOWER WOONSOCKET
CHANNEL IMPROVEMENT STUDY
GENERAL PLAN
BLACKSTONE RIVER, RHODE ISLAND

TO ACCOMPANY REPORT DATED 29 MAY 1957

SCALE: AS SHOWN

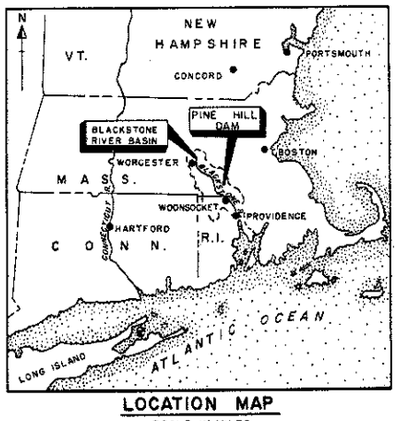
DRAWING NUMBER NE-1-1182

SHEET 3 OF 3

PLATE NO. E-6

CORPS OF ENGINEERS

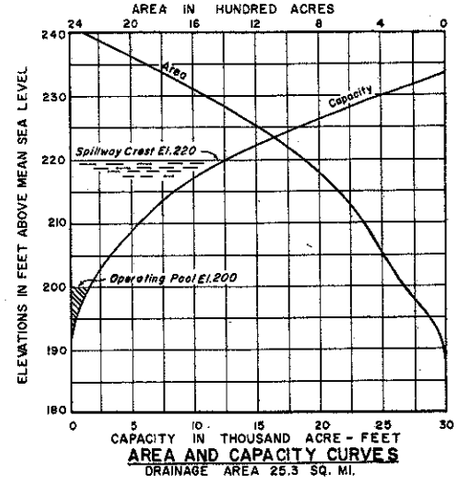
U.S. ARMY



LOCATION MAP

SCALE IN MILES

20 0 20 40



AREA AND CAPACITY CURVES

DRAINAGE AREA 25.3 SQ. MI.

N

MENDON

HOPEDALE

FLOW LINE AT SPILLWAY CREST EL. 220.0

RAISED ROAD

SPILLWAY CHANNEL

DAM

BLACKSTONE

RELOCATED ROAD

RAISED ROAD

RAISED ROAD

FLOW LINE AT SPILLWAY CREST EL. 220.0

TOWN OF MENDON
TOWN OF BLACKSTONE

MENDON

SPINDLEVILLE

MILFORD & ROAD

LEGEND

Existing unpaved roads.

Existing paved roads.

Township lines.

Reservoir at Spillway Crest El.220.0

Raised or relocated roads.

RESERVOIR PLAN

SCALE IN FEET

0 800' 1600' 2400'

NOTES:

Elevations refer to Mean Sea Level Datum.
Contour interval equals ten feet.
Topography is based on U.S.G.S. map.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
H.S.P.	S.J.C.	GFB

BLACKSTONE RIVER FLOOD CONTROL

PINE HILL DAM

RESERVOIR MAP

MILL RIVER, MASSACHUSETTS

PROJECT ENGINEER

SUBMITTED BY

CHIEF PLANNING & REPORTS BRANCH

APPROVED

CHIEF ENGINEERING DIV.

APPROVED

LT. COL. C.E. ASST. TO DIVISION ENGINEER

DATE FEB. 1957

TO ACCOMPANY REPORT DATED 29 MAY 1957

SCALE AS SHOWN

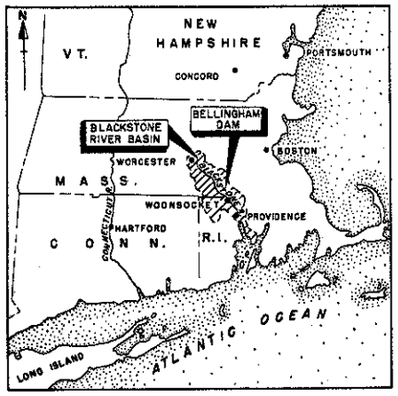
DRAWING NUMBER BE-1-1183

SHEET 1 OF 1

PLATE NO. E-7

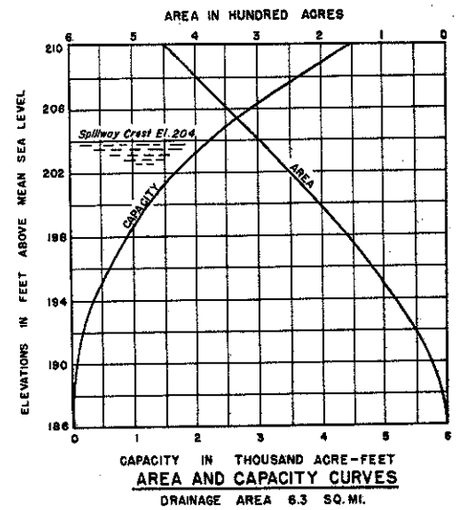
CORPS OF ENGINEERS

U.S. ARMY



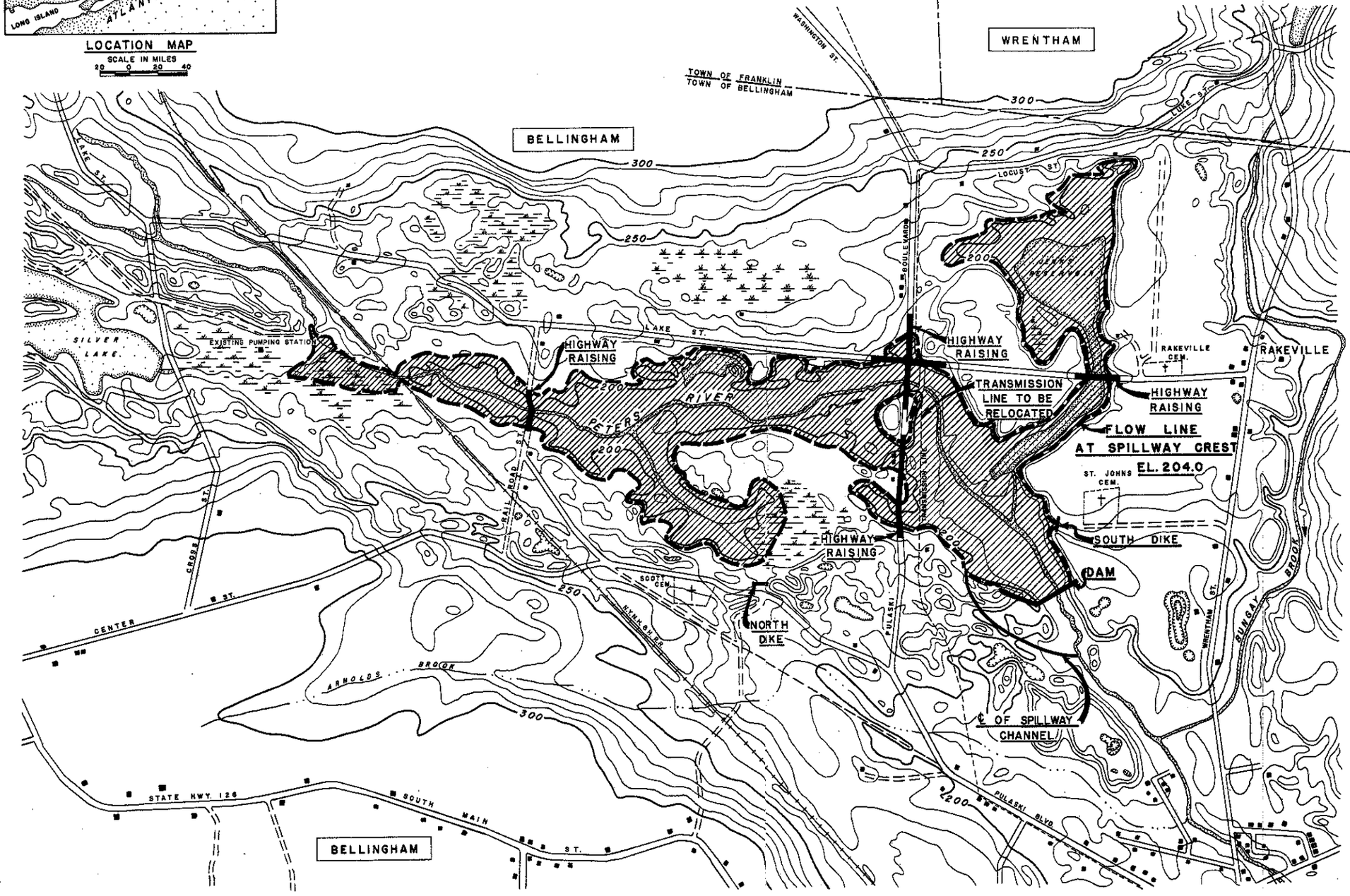
LOCATION MAP

SCALE IN MILES 20 0 20 40



AREA AND CAPACITY CURVES

DRAINAGE AREA 6.3 SQ. MI.



RESERVOIR PLAN

SCALE IN FEET 500 1000 1500

LEGEND

- Reservoir Flow Line at Spillway Crest. El. 204.0
- Highway Raising
- Existing Unpaved Roads
- Existing Paved Roads

NOTES

Contour interval equals ten feet.
Topography based on U.S.G.S. map.
Elevations refer to Mean Sea Level Datum.

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DR. BY	TR. BY	CK. BY
H.S.P.	R.G.C.	GFB

PROJECT ENGINEER

SUBMITTED BY
CHIEF PLANS & SPECS BRANCH

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
LT. COL. C.E. ASST. TO DIVISION ENGINEER

BLACKSTONE RIVER FLOOD CONTROL

BELLINGHAM DAM

RESERVOIR MAP

PETERS RIVER, MASSACHUSETTS

DATE FEB. 1957

TO ACCOMPANY REPORT DATED 29 MAY 1957

SCALE AS SHOWN

DRAWING NUMBER BE-1-1184

SHEET 1 OF 1

PLATE NO. E-8

APPENDIX F

PUBLIC HEARING DIGEST AND LETTERS OF CONCURRENCE

APPENDIX F

PUBLIC HEARING DIGEST AND LETTERS OF CONCURRENCE

This appendix contains a digest of the public hearing held at Woonsocket, Rhode Island, on November 26, 1956. Pertinent letters received in Woonsocket subsequent to adjournment of the hearing are also summarized. Letters of concurrence from the Governor of the State of Rhode Island and the Mayor of Woonsocket, and a letter of comment from the Regional Director of the Fish and Wildlife Service are included as exhibits.

All interested parties were invited to attend the public hearing to present their needs and views. Approximately 150 persons attended, including the Governor of Rhode Island, representatives of Congressmen in the area, state and local officials, manufacturers, businessmen, and representatives of local organizations and the local utility company. A flood control plan under consideration by the Corps of Engineers was presented at the hearing. All speakers expressed strong support for the immediate construction of the improvements under consideration and, in addition, urged that the plan be modified to include protection for a larger area.

DIGEST OF PUBLIC HEARING

WOONSOCKET, RHODE ISLAND

26 November 1956

Speaker	Interest Represented	Improvement Desired, Reasons Advanced, and other Remarks
Mr. Carmine J. Maisano	Senator John O. Pastore	Expressed need for protection and desired that it be left to C of E to determine measures necessary for flood control; urged reciprocal cooperation between local interests and Federal Government to expedite project construction.
Mr. Edward W. Heroux	Congressman Aime J. Forand	Requested adequate flood control for Social District and urged that benefit analysis for determination of project justification recognize importance of intangible losses.
Governor Dennis J. Roberts	State of Rhode Island	Supported plan proposed by C of E, but urged that it be modified to provide protection for a larger area.
Mr. Henry Isé, Chief	Division of Harbors and Rivers, Department of Public Works, State of Rhode Island	Expressed urgent need for immediate construction of flood protection works for Social District. Requested that studies be made to protect remaining areas by any feasible means. Also requested that water supply and pollution abatement be considered.

Speaker	Interest Represented	Improvement Desired, Reasons Advanced, and other Remarks
Mayor Kevin K. Coleman	City of Woonsocket	Supported plan proposed by C of E, but urged that plan be modified to include other existing and potential industrial areas along the Blackstone River.
Mr. G. W. Poirer, Councilman	City of Woonsocket	Favored plan proposed by C of E and expressed urgent need of flood control; requested that city and local interests, in view of Woonsocket's economic situation and recent heavy losses, not be expected to make inordinate contributions to project cost.
Mr. L. Phillip Lemieux, Chairman	Flood Control Committee, Woonsocket Chamber of Commerce	Expressed urgent need for flood protection and desired that it be left to C of E to determine necessary measures.
Mr. Arthur S. Kirk	Blackstone Valley Gas and Electric Company	Requested improvements to prevent flooding of Riverside Substation and Gas Works and to prevent washouts of river banks from Bernon Dam to Hamlet Avenue bridge. Urged that proposed plan be modified to include protection for the Hamlet District.
Mr. Charles A. Johnson	Himself	Urged that any flood control plan include multi-purpose features for power and water supply.

Speaker	Interest Represented	Improvement Desired, Reasons Advanced, and other Remarks
Mr. Christy V. Bicki	Himself and neighbors	Requested improvements on Mill River to prevent damages in East School Street area.
Mr. Raymond E. Charland	French Worsted Company	Requested that protection for the right bank of the Blackstone River be added to the proposed plan.
Mr. Frank Kearn	Himself	Requested removal of Bernon Dam and channel improvement to prevent damage on Bernon Street.
Mr. Lester A. Macktez	Himself	Desired that flood protection for Hamlet District be considered.
Writer		
Mr. Carmel Pouliot Proprietor	Home Coal Company	Requested channel excavation of Mill River, bridge removal, reconstruction of Harris Pond dam, and replacement of company land which was washed out in August 1955; urged that all possible improvements be constructed to prevent Mill River flooding in Social District.
Mr. Louis D. Gingras	Continental Engineering Service	Requested that Federal Government assume total cost of all flood-control projects.

STATE OF RHODE ISLAND & PROVIDENCE PLANTATIONS
EXECUTIVE CHAMBER
PROVIDENCE

DENNIS J. ROBERTS
GOVERNOR

April 3, 1957

Brigadier General Robert J. Fleming, Jr.
Corps of Engineers, U. S. Army
New England Division
150 Causeway Street
Boston 14, Massachusetts

Dear General:

Thank you for sending me your letter of March 20th with information that you are completing a review survey of the Blackstone River Basin, which includes the lower Woonsocket Local Protection Project. It was gratifying to learn that as a result of this survey you will recommend a new project for the protection of Woonsocket which is estimated to cost $4,100,000.

I feel that it is important to the future of Rhode Island that this additional protection be afforded to the City of Woonsocket and I therefore, wish to inform you of the state's interest in this project for inclusion in your final report.

With kindest personal regards, I am

Sincerely yours,

Dennis J. Roberts
Governor

DJR:na

KEVIN K. COLEMAN
MAYOR

EXECUTIVE DEPARTMENT
OFFICE OF THE MAYOR

CITY OF WOONSOCKET
RHODE ISLAND

April 1, 1957

Robert J. Fleming, Jr., Brigadier General
Division Engineer, New England Division
Corps of Engineers, U. S. Army
150 Causeway Street
Boston 14, Massachusetts

Dear General Fleming:

Thank you for your welcome and informative letter of March 20, 1957 with respect to your interim report which embodies the Lower Woonsocket Local Protection Project.

Please be assured that the prompt and comprehensive consideration accorded my request that this project be given the highest possible priority certainly is appreciated. The fact that the tremendous amount of work involved has been accomplished so thoroughly in the brief period which has elapsed is one more indication to me personally and to the people of Woonsocket of the cooperative attitude of the Corps as well as its ability and capacity to render efficient and effective public service. You and your staff cannot be commended too highly in this regard and our feelings are being made known to your superior by means of a copy of this letter.

With specific reference to the details of the proposed project, we are in accord with the recommended procedures, subject to such modifications as more refined studies may warrant. Assurance also is given of the willingness and ability of the City of Woonsocket to participate to the extent and in the manner prescribed, provided, however, that it is understood that such assurance is a reflection of the views and desires of the encumbent administration.

I am certain that the City Council will support this affirmation with the necessary legislation at the appropriate time.

Again thanking you for your cooperation in this extremely important matter, I am

Sincerely yours,

Kevin K. Coleman

Kevin K. Coleman
Mayor

KKC:mtb

cc: Chief of Engineers

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

OFFICE OF REGIONAL DIRECTOR
BLAKE BUILDING
BOSTON 11, MASSACHUSETTS

IN REPLY REFER TO:

REGION 5
NEW ENGLAND STATES
NEW YORK
PENNSYLVANIA
NEW JERSEY
DELAWARE
WEST VIRGINIA

March 18, 1957

The Division Engineer
New England Division
U.S. Corps of Engineers
150 Causeway St.
Boston 14, Mass.

Dear Sir:

Reference is made to your letter dated 15 March 1957 in which you requested the comments of this Service in relation to local flood protection for the Blackstone River at Woonsocket, Rhode Island.

It is the opinion of this office that the project will have little or no impact on fish and wildlife resources. Therefore, detailed comments by this office are considered unnecessary.

Thank you for calling this matter to our attention.

Very truly yours,

D R Gascoyne

D. R. Gascoyne
Regional Director